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HISTORY OF DECARBURIZING IRON.

The subject of greatest interest, at this time, to the engineering profession, and to the public (excepting only the construction of the new Cabinet), is the cheapening of iron in a malleable form. The success of the Ellershausen process of making malleable* pig-blooms, by mixing ore with iron as it runs from the blast furnace, has stimulated an amount of experimenting entirely unprecedented in the history of the iron manufacture. We venture to say, that in every considerable iron works in the United States, the ore process has been more or less tried, in some form, during the last three months, and that in at least half these establishments the Ellershausen turn-table, or some other mixing apparatus is in process of construction or in experimental use.

Nitrates, for decarburizing crude iron, are also the subject of experiments, either upon the plan of Heaton, or as an auxiliary to puddling. Nearly every expert in iron working has a scheme of his own, and the Patent-office is getting as crowded with iron and steel papers as with claims for velocipedes.

Just at this time, therefore, an abstract of the history of purifying crude iron, will be read, we think, not only with interest, but with profit. Many thousands of dollars that would otherwise be wasted in the attempt to patent processes that are old, may be saved by a careful reference to patents already in existence. The official and most carefully prepared abstracts of specifications, issued by the British Patent-office, may be fairly presumed to embrace nearly every invention of value. Probably no process of sufficient novelty to become the subject of a patent, has remained unprotected, and the British list is likely to embrace the inventions not only of Britain, but of America, France and Germany, because improvements in the iron manufacture are worth more, and will pay better, in England, than in any other country. American inventors generally obtain patents in England first, to be certain of securing their claims there. Of course there are many experiments that never become the subject of patents or publications—but mere experiments that have not been able to lead to successful practice, are no bar to the issue of patents to other and successful experimenters with the same means and in the same direction. And although the publication of the many unrecorded trials and schemes that have been made and suggested would be of interest, it would not be of very great value as compared with a record of patented inventions; there is certainly no means of getting at the unrecorded schemes, except the laborious and costly means of patent suits, which from time to time call up some of the more important ones—generally with little practical effect.

We propose to give abstracts of the "Abridgements of the Specifications relating to the Manufacture of Iron and Steel," in the department of decarburizing and purifying crude iron so as to make it malleable and tenacious. For convenience of reference we shall prefix to each abstract a very brief statement of what the patent is about—the *gist* of the matter; and although

* That is to say, malleable after being sufficiently heated to be got into the form of a puddle ball.

we shall omit all merely formal parts, we shall quote, in the words of the patent itself, all those statements that form the essence of the invention, and would be the subjects of legal claims.

DECARBURIZATION AND PURIFICATION BY MEANS OF CINDER, ASHES, SALT, SILEX, POTASH AND CLAY.

PAYNE, JOHN.—1728, Nov. 21. No. 505.

The improvements in the manufacture of iron consist "in putting certain ingredients into fusion with pig or sow iron; videlicet, the ashes of wood and other vegetables, all kinds of glass and sandever, common salt and rock salt, argile, kelp, and pot ash, slegg or cinders from iron furnaces, and forges, proportionable parts of the said ingredients being put into fusion or melted with pig, sow, or other brittle iron, which will make the like change as charcoal does in the fire called the finery in common forges, and will render the same into a state of malleability, as to bear the stroke of the hammer, to draw it into barrs or other forms att the pleasure of the workman, and those or other barrs being heated in the said melted ingredients in a long hott arch or cavern, as hereafter is described; and those or other bars are to pass between two large mettall rowlers (which have proper notches or furrows upon their surfass), by the force of my engine hereafter described or other power, into such shapes and forms as shall be required."

NOTE.—*The "finery" referred to is the run out or fining fire still in use in England—blowing air down upon melted iron to partially decarburize it preparatory to farther refinement. The Bessemer process is a vast enlargement of this idea.*

The "long hott arch" described in another part of the patent, is a reverberatory furnace. This subject and other features of the iron manufacture will be taken up in another series of articles.

Kelp is calcined sea-weed ash. "Argile" or argil is alumina.

FINERY IRON MIXED WITH SLAG, SCALES, SAND, LIME AND OTHER FLUXES, AND SOMETIMES WITH MALLEABLE SCRAP, AND MELTED IN CRUCIBLES.

WOOD, JOHN.—1761, Feb. 5. No. 759.

"A way of making malleable iron from pig or sow metal" and of making "the malleable iron hard or soft or of other required qualities," by "raw pitt coal," some of the operations being "preparatory" and others "peculiarly essential."

The pig iron when prepared as hereinafter mentioned, is put into close vessels of clay and mixed with the fluxes. The crucibles being hermetically sealed, are placed in an air furnace, and their contents are melted; the fluxes and impurities form slag, and "the iron is brought into a tough and malleable state," and then is wrought into bars under the forge hammer. The preparatory operations are,—

1st. "I take pig or sow iron." "This I flourish or heat and work in a common finery, with a blast" and coal fire until it is refined and "brought near to a malleable state," or brought to nature. It is then melted in the close vessels above described.

2d. "To the iron thus flourished I sometimes add a due proportion of small pieces of malleable iron, when the cast metal" is very brittle, and the coals very sulphurous.

3d. "I also take the same cast metal, and melt it down in an air furnace," and then I reduce it "into small grains (according to art) by pouring it into water upon a wheel or roller turned briskly round. The granulated metal" is "mixed with various fluxes, according to its nature and the uses for which the iron is intended, as with iron slag or cinder, scales or scoria of iron, fusible sand and lime, kelp, soaper's waste." The fluxes or additions "I put with the granulated metal into close vessels, and work" in the air furnace, as above described.

4th. The cast iron is sometimes "formed into thin plates," which are broken "into small pieces and put into the pots," with "due proportion of fluxes," and so "reduced to a malleable state."

NOTE.—*Mixing wrought iron scrap with cast iron finds its practical development in the Siemens-Marten process.*

The granulation of iron by means of water and the revolving table, is now practised in preparing iron for crucible steel making and other purposes.

The soaper's waste referred to, is wood ashes containing potash or soda.

The "raw pitt coal" referred to in the title, is used in the finery.

MAKING CAST IRON MALLEABLE WITHOUT BLAST, BY GRANULATING IT AND REPEATEDLY MELTING IT IN POTS WITH CINDER, SCALES, SAND, LIME, ASHES AND OTHER FLUXES, AND SOMETIMES WITH SCULL OR SCRAP IRON.

WOOD, JOHN AND CHARLES.—1763, July 29. No. 794.

The pig iron is either granulated by being poured hot into cold water, or pounded with heavy stampers. Scull or cinder is pounded in like manner. If the iron be of red short quality it is sprinkled with strong lee of kelp, and then flourished or melted in closed pots with proper fluxes, such as slag scales or scoria of iron, sand, lime, kelp, or soaper's waste.

If this operation does not sufficiently flourish or reduce the iron to nature, it is again broken by the stampers, and flourished a second or third time.

The iron is then again pounded, and sometimes mixed with pure scull or scrap iron, and is fit for chaffing or melting in the close pots, with a covering of clay, when it becomes "perfectly tough and malleable," and is to be "wrought under the hammer into half blooms."

MAKING PIG IRON MALLEABLE IN A REVERBERATORY OR AIR FURNACE WITH RAW PIT ONLY.

CRANAGE, THOMAS AND GEORGE.—1766, June 17. No. 851.

"The pig iron is put into a reverberatory or air furnace, built of proper construction, and, without

the addition of anything more than common raw pit coal, is converted into good malleable iron, and being taken red hot from the reverberatory furnace to the forge hammer, is drawn into bars of various shapes and sizes, according to the will of the workman."

NOTE.—*We here see the importance of considering the state of the art at the time when the invention was made. After Cort had invented puddling, Cranage's specification would have been, in general terms, a description of that important invention. But before Cort's specification was issued (see abstract of it further on) we doubt if Cranage's would have guided any one "skilled in the art," to puddling. The two words "is converted" stand for the whole process of stirring up the iron with the rabble. The use of raw pit coal, which gave such great value to Cort's invention, is, however, mentioned.* (*See Percy's Metallurgy, Iron and Steel, p.* 636.)

MORE RAPID DECARBURIZATION IN THE FINERY BY THE USE OF MORE TUYERES AND A MORE DIFFUSED AIR BLAST.

COCKSHUTT, JOHN.—1771, May 2. No. 988.

The patent first describes making malleable iron (if "right managed") in the finery, from ore mixed with cinder.

Pig iron is made into wrought iron by heating sufficient for a bloom or loup in an air furnace, or with bellows. The heated metal is then put into a finery or bloomery, and melted with charcoal until it comes to nature, when it is sunk into a bloom and another charge is supplied. The finery is made of metal plates, open on two or more sides, so that men may work at least on two sides. "Instead of having only one tuiron" for the blast, there are "several tuirons, so as to direct the wind from the bellows to operate upon the iron in every part of the fire." The number of tuirons is regulated according to the nature of the iron. "This new finery, and new method of working, requiring a greater supply of wind than the common way," an air reservoir with valves is constructed to regulate the blast, the supply being provided by the requisite number of bellows.

NOTE.—*Ninety-eight years ago this iron worker had a better appreciation of the theory of air refining, which has since been so successfully worked out by Bessemer, than some of Bessemer's competitors have to-day. The idea of diffused blast is one of the leading ideas of Bessemer's invention, and if Cockshutt had blown a little harder, so as to penetrate the metal, he would have made a loup malleable in whole or in part, but he would not, of course, with any means then known, have produced his malleable metal in a liquid state. Some of the early claimants of the Bessemer invention used but one tuyere, and did not diffuse the blast.*

MAKING "STEEL" OR A HIGH IRON LIKE PUDDLED STEEL DIRECTLY FROM PIG IRON IN A BLOOMERY.

GOODYEAR, JAMES.—1771, Dec. 20. No. 1,000.

"Place the pig or cast iron in the fire as when you intend to make bar iron, but the blast of the bellows must not be so strong. When some of the iron is sunk in the fire you must work from the bottom as when you make iron, but keep melting iron as at first. When there is a sufficient quantity to make a loup let the whole sink to the bottom," when it may be fused and shingled, and drawn as common iron. "The fire must be kept as free from cinder as possible. The addition of common salt and other saline substances," and animal or charcoal dust, improves the steel. "The finest steel, after it is made as above, may be converted in the same manner as common steel is made from bar iron."

NOTE.—*The decarburized iron appears to be recarburized by keeping the pig iron melting above it after it is sunk in a loup, and also by charcoal dust, and it may be further recarburized by "converting."*

Steel is here mentioned by name, for the first time in the patent records.

MAKING MALLEABLE IRON FROM PIG, WITH RAW COAL OR COKE, WITHOUT GRANULATIONS OR ADMIXTURES, FROM BROKEN AND WASHED FINERY IRON.

JESSON, RICHARD, AND WRIGHT, JOHN.—Oct. 30, 1773. No. 1,045.

Pig iron, or scull or cinder iron, is melted in a finery with blast and with raw coal only, and taken out in lumps while hot, beaten into plates by a flat stamp or hammer, broken small and well washed by hand or in a rolling barrel. The broken metal is then melted in an air furnace or in closed pots and then "beaten into bars from a chaffery in the common way." If the metal be red short or cold short, it is mixed in the pots with the proper quantity of scrap or nutt iron.

NOTE.—*There appears to be nothing new or feasible here, except the washing in a rolling barrel, if red short iron, which the patentee mentions, was used; the lumps taken out of the finery and hammered would not require much farther breaking up; even if the carbon were sufficiently removed to render the mass malleable. If he made this process work, he has not told us how.*

FLUID IRON FROM THE SMELTING FURNACE STIRRED AND WORKED (AND IT WOULD APPEAR) PUDDLED IN AN AIR FURNACE BY THE AID OF AIR BLAST AND WATERY VAPOR.

ONIONS, PETER.—1773, May 7. No. 1,370.

Two furnaces are used, a common smelting furnace and another furnace of stone and brick, "bound with ironwork and well annealed," into which the fluid iron or metal is received from the smelting furnace. "A quantity or stream of cold water is run or put into the cistern or trough under the ash-grate." The furnace is then charged with fuel and closed up, and the doors luted with sand. The blast is then admitted below the grate, and when the furnace is sufficiently heated the liquid iron metal is taken from the smelting furnace in ladles, and introduced through an aperture, which is then closed. The blast and fire are then used "until the metal becomes less fluid and thickens

into a kind of paste, which the workman by opening the door turns and stirs with a bar or other iron instrument, and then closes the aperture again, and must apply the blast and fire until there is a ferment in the metal." If no ferment ensues, a blast of cold air is to be blown upon the metal from an extra pipe. "As the workman stirs the metal" the scoria will separate, "and the particles of iron will adhere," these the workman "must collect or gather into a mass or lump." This is to be reheated to a white heat, and then taken to the forge hammer and forged into malleable iron. Instead of running fluid metal into the furnace, pig iron may be placed and melted there, and operated upon as above described. The forge hammer is connected with an air cylinder whose piston is attached to the helve, and is worked by it. The cylinder is either placed above the helve and acts as a buffer on the compression principle, or is placed below and on the exhaust principle draws down the hammer.

NOTE.—*It is difficult to see, from the patent records, why this patent does not in a great degree anticipate Cort's. Onions' drawings show a reverberatory furnace, and not a bloomery or finery fire in which the fuel and iron might be mixed together. The stirring with a bar, the ensuing fermentation, the coming to nature and the aggregation of the puddle ball, are distinctly described.* (*See also Percy's Metallurgy, Iron and Steel, page* 638.)

The direct blast of air would not be considered an element in puddling, as explained now-a-days by Mr. Siemens. (*See Van Nostrand's Mag., Vol.* 1, *No.* 1, *page* 38.)

A considerable quantity of steam must have been formed under the grate, and passed over with the flame. The modern Pomeroy process revives this practice.

Peter Onions was a successful iron maker; his knowledge of the subject—96 years ago—was certainly in advance of the times.

PUDDLING.

CORT, HENRY.—1784, Feb. 13. No. 1,420.

On Jan. 17, 1783, Mr. Cort patented a process of faggoting bar iron and of welding by *rolling in grooved rollers*. The title of the puddling patent of 1784 is as follows: "Shingling, welding, and manufacturing iron and steel into bars, plates, rods, and otherwise, of purer quality in larger quantities by a more effectual application of fires and machinery, and with greater yield than any method before attained or put in practice."

The patentee uses a reverberatory furnace heated by coal, having a concave bottom, into which the fluid metal is run from the furnace, or pig iron is put in and melted. When the workman discovers, by looking through a hole, that the metal is sufficiently melted, he opens an aperture, by preference, in the bottom of the door, and works and stirs up the mass of metal with iron bars, "which operation is continued, as may be requisite, during the remainder of the process." An ebullition of the metal soon takes place, and the stirring with the bar is continued till the metal is "flourished and brought to nature," when it is collected in loops and drawn out of the door. All small pieces that may happen to remain are cleared away. These with scull and parings and nut iron may be thrown into the furnace and worked up with the iron while it is being brought to nature. The iron so prepared may be stamped into plates, broken, piled, and worked in an air furnace, in pots, or without. "But the method invented by me is to continue the loops in the same," "or reheat them" in another air furnace to a welding heat, and then shingle them into half blooms or slabs. These may be heated in the chaffery, "but my new invention is to put them again in the same or another air furnace" from which the half blooms or slabs are taken, and either drawn down under the hammer or rolled through grooved rollers at a welding heat. Iron and steel so prepared is of good quality, whether the blistered steel be made from fagoted iron or from iron made by the above process. "The whole method" is "completed without using finery, charcoal, cokes, chaffery, or hollow fire without requiring any blast" or "the use of fluxes."

NOTE.—*This patent, and the patents of Nielson, (hot blast), Heath (carburet of manganese in steel making), Bessemer, Mushet, (recarburization), Siemens, and we may perhaps add, the process of Ellershausen, are the most remarkable in the history of the iron manufacture. With the exception of Bessemer's process, Cort's has made a greater revolution in refining iron, and has stimulated and cheapened production in a greater degree than any other process.*

Puddling "without the use of fluxes," however, as specially stated by Cort, has already gone out of use, and the improvements that are created by or will grow out of the Ellershausen process, are likely to revolutionize puddling to as great a degree as puddling revolutionized blooming. In the best practice, the ore used in fettling supplies the waste caused by the oxidation of iron in the puddling furnace, and improves the quality of the product. More recent experiments in the puddling furnace, with as much as 30 *per cent of ore, pulverized and worked into the melted iron, have increased the yield from six to eight heats per day, thus decreasing the cost, and at the same time making good the waste of iron, and improving the quality of the product.*

(To be continued.)

EMPLOYMENT OF COTTON WASTE AS MANURE.—M. Dupont-Poulet, a French cotton spinner, has for the last ten years used his cotton waste for seed beds and early crops. He mixes it carefully with stable manure, and thus avoids, as he says, the burning and the chills which manure alone often causes. M. Dupont-Poulet's example has been followed by his neighbors, some of whom have gone beyond him; one of them had the idea of using cotton in the forcing of asparagus, that is to say, he spread a layer of cotton waste, about eight inches thick, over one of his asparagus beds, and found that the snow when falling upon it disappeared very rapidly; he was able, without any other covering but the cotton, to gather fine, tender, well-flavoured asparagus in the midst of winter.

POWER CONSUMED BY DRILLS.

EXTRACTS FROM A REPORT BY CAPTAIN CLARINOAL, PROFESSOR IN THE ARTILLERY AND ENGINEERS' SCHOOL AT METZ.

Translated by John B. Pearse.

In order to ascertain the power required to bore a hole of given diameter in wrought iron, the following points must be considered: The kind of iron, the direction in which the hole is bored, its depth and diameter, the lubricating material, the form of the drill and its speed. The experiments were conducted with an ordinary drill press, while the power consumed was measured by Morin's dynamometer. The wrought irons used in the experiments were a very hard variety, forged under the steam hammer at the forges at Montigny-les-Metz, and a soft rolled iron from the iron works at Abainville. The drills used were center-bits and a flat drill of exactly equal diameter, driven at the same speed, and lubricated with oil and afterwards with soap-suds. Cast iron, bronze and steel were then similarly experimented on. The conclusions derived from the above experiments were the following:

(1.) The amount of power necessary to drill with a center-bit into wrought iron, remains quite constant so long as the depth of the hole does not exceed 0.05 meter: as soon as this limit is passed the required power increases rapidly.

(2.) The power consumed in boring across the fibres is almost independent of the depth of the hole; the original power is, however, somewhat greater than that required to drill in the other direction. Since however the power required in boring in the latter direction increases greatly with the depth, the total power required to bore a given hole across is much less than that required to bore it in the direction of the fibres.

(3.) The power required to bore a hole of given diameter increases with the hardness of the iron. The use of oil to lubricate the drill diminished the power required about 0.2, as compared with that required when soap-suds were used. This holds good as well in hard as in soft wrought iron.

(4.) The results obtained with center bits hold good also for flat drills; the latter, however, require a greater power than the former, as is shown below.

(*a.*) The power required by a flat drill 0.025 meter in diameter, to bore a hole in the direction of the fibre, is about 1.25 times as great as that required by a center bit of similar diameter operating under similar circumstances.

(*b.*) The power required by a flat drill, 0.025 meter in diameter, to bore across the fibres, is about 1.4 times as much as that required under similar circumstances by a center bit.

(*c.*) When the diameter of the drills is 0.015 meter the above quantities become 1.6 and 1.8 respectively, which seems to show that small drills require a comparatively greater power than large ones. When the diameter of the drills is 0.008 meter, the above proportion becomes 1.52, which corroborates the above conclusion.

These results agree with practice, since the flat drill is commonly used only for holes 0.008 meter in diameter, and under, which do not permit the use of the center bit or pin drill.

EFFECT OF VELOCITY.—In order to estimate the effect of the velocity of the drill, a drill of 0.025 meter was driven at a speed (on its circumference) of 0.22 meter per second, and also at a speed of 0.125 meter. The power consumed per second is clearly less at a slow speed than at a high one, but the power required to bore a given hole is about the same in each case. For instance, the power required to bore a hole 0.0074 meter deep (in the direction of the fibres) at a speed of 0.22 meter, amounted to 23.49 meter-kilogrammes, and to 21.8 at a speed of 0.125 meter: across the fibres, the power required at the high speed was 24.3 meter kilogrammes, and 22.3 at the low speed.

It appears then that the power required to drive the drill at either speed is not very materially different. Hence, the reporter concludes that the speed of the drill should be as great as possible, to diminish the resistance offered by the metal, and that the feed should be heavy, and both so far as possible without destroying the edge or boring too rough a hole.

The average advisable circumference speed of drills is 0.12 meter per second in wrought iron, 0.06 meter in cast iron and 0.15 to 0.18 in bronze (gun metal). When these velocities are exceeded the drill is apt to become soft, and when they are not reached the work is not economical.

The pulleys of the drill press used for these experiments are so calculated that the following circumference speeds of drills could be obtained:

	Millimeter.	Millim.	Milim.
Diameter of drill...	3 to 10	10 to 20	20 to 25
Speed at circumference.....	34 to 115	77 to 154	104 to 183
Feed	16	10	7.5 milim. per min.

POWER DEMANDED BY BORING MACHINES.—As the hardest wrought iron necessitates the most power, M. Clarinoal based his experiments on that forged at Montigny, which is generally acknowledged to be very hard, and compiled the following tables from the results of numerous experiments on this wrought iron, on cast iron and on bronze. The first table denotes the power required by a center-bit in boring a hole of given diameter and depth, while the second table gives the corresponding results in the case of a flat drill.

Table showing power required in one second by a center-bit boring at different depths in hard wrought iron, ordinary gray cast iron, and gun metal (11 parts tin and 100 parts copper), the feed being one millimeter per minute.

Depth of hole.	Hard Wrought Iron. Diameter of hole.						Ordinary Gray Cast Iron. Diameter of hole.					Gun Metal. Diameter of hole.				
	millim. 44	millim. 35	millim. 25	millim. 15	millim. 10	millim. 8	millim. 35	millim. 25	millim. 15	millim. 10	millim. 8	millim. 45	millim. 40	millim. 25	millim 15	millim 8
Millim.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.	Meter-kilogr.
5	11	7.4	4.7	2.23	1.85	1.57	3.6	2.9	1.1	0.6	0.5	6.1	6.	2.4	1.	0.4
10	11	7.4	4.7	2.23	1.85	1.57	3.6	2.9	1.1	0.6	0.5	6.1	6.	2.4	1.1	0.4
15	11	7.6	4.7	2.23	1.85	1.57	3.6	2.9	1.1	0.6	0.5	6.1	6.	2.4	1.2	0.5
20	11	7.6	4.7	2.23	1.85	1.57	3.6	2.9	1.1	0.6	0.55	6.2	6.1	2.45	1.3	0.6
25	11	7.6	4.7	2.23	1.85	1.60	3.6	2.9	1.1	0.6	0.60	6.2	6.2	2.5	1.5	0.7
30	11	7.9	4.8	2.23	1.85	1.63	3.6	2.9	1.1	0.6	0.67	6.4	6.3	2.6	1.7	....
35	12	8.3	4.8	2.24	1.90	1.66	3.6	2.9	1.1	....	....	6.5	6.4	2.7	1.9	....
40	13	8.8	4.9	2.25	1.90	1.70	3.6	2.9	1.1	....	....	6.6	6.4	2.8	2	....
45	14	9.6	4.9	2.30	....	1.75	3.6	2.9	1.1	....	....	6.6	....	2.9	2.3	....
50	....	....	5.	2.35	....	1.80	3.6	2.9	1.1	....	....	6.7	....	3.	2.5	....
55	....	....	5.	2.40	....	1.90	3.6	....	....	....	....	6.7	....	....	2.7	....
60	....	....	5.1	2.45	....	2.	3.7	....	....	....	....	6.8	....	....	2.9	....
65	....	....	5.2	2.50	....	....	....	....	....	....	....	6.8	....	....	3.1	....
70	....	....	5.3	2.70	....	....	....	....	....	....	....	....	....	....	....	....
75	....	....	....	2.80	....	....	....	....	....	....	....	....	....	....	....	....
80	....	....	....	3.	....	....	....	....	....	....	....	....	....	....	....	....
	Lubricated with soap-suds.						Bored dry.					Bored dry.				

Table showing power required in one second, by a flat drill, boring at different depths in hard wrought iron, ordinary gray iron, and gun metal (11 parts tin and 100 parts copper), the feed being one millimeter per minute.

Depth of Hole.	Hard Wrought Iron. Diameter of hole.			Ordinary Gray Cast Iron. Diameter of hole.		Gun Metal. Diameter of hole.	
	7.5 millim.	5.5 millim.	3 millim.	7.5 millim.	5.5 millim.	7.5 millim.	5.5 millim.
Millimeter.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.	Meterkilogramme.
5	1.9	1.5	1.2	1.08	1.	0.6	0.5
10	2.	3.	1.8	1.08	1.	1.	0.7
15	2.3	3.5	2.4	1.08	1.	1.2	0.9
20	3.	4.	....	1.08	1.	1.4	1.1
25	8.	5.	....	1.08	1.	1.9	1.7
30	9.	....	....	....	....	2.4	2.1
	Lubricated with soap-suds.			Bored dry.		Bored dry.	

As the results in wrought iron apply to hard iron, they should, according to M. Clarinoal, be diminished by about one-tenth to apply to soft wrought iron; and as the experiments were made with soap-suds as lubricating material, the powers given should be diminished, say one-fifth, when oil is used as the lubricator.

In the above tables, the power consumed by boring the given holes with a feed of *one millimeter per minute*, is taken as unity. Therefore, to ascertain the power required *in a second*, with a given feed, it is only necessary to multiply the figures in the tables *by the depth fed per minute*.

A comparison of results obtained with borers of both kinds of the same diameter (0.25 meter), shows that the power required to drive a flat drill in cast iron is 2.6 times as much as that required to drive a center bit.

Experiments on hard white cast iron, showed that the power required to drill such iron was very nearly double that stated for gray cast iron. It appears from the tables that the power required to drill cast iron is nearly constant, no matter what the depth of the hole may be.

The experiments made on steel showed that, under similar circumstances, more power was required to drill shear or soft steel than to drill hard cast steel, and that flat drills increased the power necessary by at least one-third ($\frac{1}{3}$).

Capt. Clarinoal concludes with the following remarks:

(1.) Nearly the same power is required to drill hard wrought iron and hard cast steel.

(2.) The power required to bore soft steel is not much greater than that required for hard wrought iron, but the former increases rapidly with the depth of the hole. Thus, at a depth of five or six millimeters, the power consumed in drilling with soap-suds in soft steel, a hole fifteen millimeters in diameter, is equal to that consumed in boring one of twenty-five millimeters in diameter in hard wrought iron.

HYDRAULIC PIPE ENGINEERING. — Messrs. Walsh and Watkins, contractors, have laid a 11-inch plate iron water-pipe, from a point on a mountain side in Tuolumne county, California, down the mountain, under a creek and up the ascent on the other side, in all 8,800 feet in length, and under a perpendicular pressure at the lowest point of 684 feet.—*Mining and Scientific Press.*

PURIFYING IRON ORES.

ON FLUOR SPAR AS AN AGENT FOR PURIFYING IRON ORES CONTAINING PHOSPHORUS.

By H. Caron.

Translated by John B. Pearse from "Comptes Rendus" and "Berg and Hütten Zeitung."

I have already had the honor of communicating to the Academy the results of my attempt to improve those pig irons which are smelted from non-manganiferous ores, which ores form a great part of those occurring in France. I was enabled to show by exact experiments that the addition of manganese (in the form of its oxides) to the furnace charges had the effect of removing or keeping out of the iron an appreciable quantity of the sulphur and silicium present in the ores and fuel. Since that time the experiments of the laboratory have been carried out in the trade, and there are now few furnaces where the addition of the oxides of manganese has not brought about a marked improvement in the quality of the pig metal.

I found at that time that the oxides of manganese had no effect in carrying off phosphorus, although they acted so favorably upon sulphur and silicium. I therefore endeavored to find some means of effecting the removal of the former body, and now confine myself to the communication of the only method which has given satisfactory and certain results.

The ores of iron which contain phosphorus, contain it principally in the form of phosphates of iron, alumina or lime; in order to combat the evil effects of these phosphates it was customary to mix large quantities of lime with the ores, as lime was commonly supposed to have some effect in this direction. Unfortunately, however, these phosphates of lime are slightly, or rather not at all fusible, and the addition of large quantities of silicious ore was necessary to cause the slag to flow readily.

What is now the result in the blast furnace? Phosphates, silicia and carbon are in immediate contact—just as in Wöhler's method of preparing phosphorus; there result therefore silicious slag and iron, carbon and free phosphorus, which latter naturally combine to form a cold short pig metal. It is certain that this re-action actually occurs in the furnace as the analysis of slags, from ores containing a good deal of phosphorus, show very little of this element, while it is very rare that the same is not present in injurious quantity in the iron. Let us suppose

that lime takes up the phosphorus of the ores, the problem then before us is to find some fusible substance which contains no silica, and can dissolve the phosphate of lime, without decomposing it. It seemed *a priori*, as if fluor spar was such a substance, and I endeavored to ascertain its virtues as follows:

(1.) A mixture of phosphate of lime and fluor spar was placed in a crucible of compressed coke, which was placed in a clay crucible and surrounded with charcoal.

(2.) A mixture of phosphate of lime with silica was placed in a similar crucible. Both crucibles were then exposed to the heat of a cast steel furnace, with the following results: The crucible containing the phosphate of lime with silica was eaten completely through, and the phosphorus had disappeared. The other crucible, on the contrary, was whole, merely a little of the coke alone having been melted off; the fused mass contained phosphorus and phosphoresced when struck with a hammer. It was therefore certain that fluor spar dissolved the phosphate of lime without decomposing it.

I accordingly experimented as follows upon phosphate of iron:

(1.) A mixture of phosphate of iron with lime and fluor spar, was placed in a brasqued crucible.

(2.) A mixture of phosphate of iron with lime and silica, was also placed in a similar crucible.

These mixtures treated as before gave the subjoined results. The crucible containing silica was eaten through, and the graphitic button of iron was easily broken up under the hammer. The other crucible was whole, and the resulting button was somewhat flattened out before it could be broken up, while the fracture showed that the iron was mottled. The first button contained three (3) times as much phosphorus as the second, which on being remelted became entirely white. The influence of the fluor spar was therefore established beyond a doubt.

On operating analogously upon ores containing phosphorus, which always contain a comparatively small quantity of phosphates, an appreciable improvement resulted from the substitution of the fluor spar for silica, although the improvement became less marked, the less phosphorus the ore contained. Not only are these phosphates soluble in fluor spar but also sulphates and arseniates; even alumina is taken up by this agent and retained in the slag without the aid of silica.

GOVERNMENT CONTROL OF TELEGRAPHS IN ENGLAND.—The acquisition of the telegraphs of the United Kingdom by the Government, and their being placed under the Post-Office administration, had been mooted for some time; last spring, action began to be taken and inquiries made; the result has been a large correspondence and cross-fire of pamphlets between the Post-Office and telegraph companies. This cleared the way for the government bill, which, after being committed, and much time spent in discussing and amending its objects, finally passed both Houses of Parliament and became a law. It empowered the Post-Office to buy up all the telegraph systems of the various telegraph companies of this country who were willing to sell their property. This all have been found willing to do, and meetings have been held authorizing the directors to agree to the Post-Office terms, which have been usually a twenty years' purchase on present rates. The final amount to be paid to the various telegraph companies has to be settled by arbitration. Agreements have also been entered into between the Postmaster-General and the various railway companies, by the which it is settled that all wires belonging to the railway company, and used by them for their special services of train signalling or otherwise, shall remain theirs, in addition to which the railway company will in future maintain all wires, poles, and telegraphs, the property of the Government, passing over their lines. Under this arrangement, there may be perceived the following curious change—what the telegraph companies formerly did and still do for the railway companies the railway companies will now do for the Government.

The Post-Office are making great internal changes preparatory to taking charge of the telegraph system, and to complete the transfer it is now only necessary to bring into Parliament the bill for providing the necessary funds. It is anticipated that this will be done very early in the year, and by July 1 it is most probable that the various telegraph companies will have handed their systems over to the Government.—*Mechanics' Magazine.*

THE HEATON PROCESS.—The discussion on the merits of this process, still occupies many dreary pages in the London newspapers. Nothing very new or important has been elicited. We shall, in a future number, give a very brief abstract of the situation up to date.

THE MOLDAU SUSPENSION BRIDGE AT PRAGUE.

The peculiarity of this bridge is that there is only one pier, or tower, and that is in the center of the river, so that the bridge is really formed of only two half spans, each half being in the clear 305 feet six inches, the thickness of pier being eighteen feet at the crown. The distance from face to face of abutments is 629 feet; on each shore there is no room for the anchorage chains, &c., to extend such a distance inland as would be required if towers were used instead of abutments. And it was considered advisable to have only one pier or tower in the river, to avoid as much as possible intercepting the ice.

The particulars of the work are thus given in "Engineering": The bridge is for foot passengers only, and has a clear width of eleven feet from end to end. Each column of the pier being built clear of this width involves the chains being wider apart, in plan, in the center of the bridge than at the abutments; this arrangement gives the structure considerable resistance to any side motion that might be caused by the wind.

The abutments and anchorages are built of stone, with concrete fillings. The pier in the center of the river is also of stone from its base to the underside of the superstructure, where the ornamental cast-iron tower commences. The tower consists of two pillars or columns connected at the top by an open cast-iron girder, and each column consists of four standards firmly connected together and bolted at their bases to the pier. The height of the bridge above the highest level of water is six feet six inches, and height of tower from same level is 63 feet.

The chains are of steel, and formed of links in 21 feet lengths by four and a half inches deep by one inch thick, having heads and eyes, and steel pins of three and a half inches diameter. The main chains have each six links in width, and they are connected to straight chains which pass direct to the base of the tower. These straight chains are applied to prevent as much as possible the rising or moving of the curved chains when an unequal load is passing over the bridge. The straight chains have only two links each of the same dimensions as the links of the curved or main chains. The main chains are supported on the tower on a saddle resting upon seven cast-iron rollers, each three feet long and four and a half inches diameter, and carefully turned, from whence they pass to the abutments, where they rest on other saddles, and from thence they pass to their anchorage. The anchorage for each end of each main chain consists of seven steel plates resting upon two cast-iron girders or bed plates, the four bed plates being connected together by cast-iron girders. The connections for the adjustment of the lengths of the main chains are near the tower and in the abutments, and for the straight chains at the base of the tower, and can be adjusted by means of steel gibs and keys.

The footway or platform is formed of two main longitudinal parapet girders in one continuous length from end to end of bridge, and rests upon cast-iron cross girders twenty-one feet apart, which are suspended by wrought-iron suspension rods one and a half inch. diameter, to the main chains. The main or parapet girders are one foot six inches deep, the top and bottom flanges being formed each of two pieces of pine, having a total sectional area of 72 square inches. The diagonals are also of pine, six inches by three inches, fitted into cast-iron shoes cast on the ends of the C I verticals; these have a wrought-iron bolt one inch diameter passing through them, firmly connecting the bracing to the flanges. The verticals are seven feet apart, and at these distances there are cross timbers acting as girders to support the planks of the footway, so that there are two timber beams and one cast-iron girder in every 21 feet to carry the planking of the footway. The planking is four inches thick, and on this is boarding one and half inch. thick, laid crosswise. The footway, besides being suspended to the chains, is also connected to the base of the tower by means of four diagonal rods, which allow it to move only vertically to a slight extent, but not horizontally.

The quantity of cast iron contained in the tower saddles, anchorage girders, cross girders, verticals in parapet girders, &c., is 108 tons. The steel in the chains, plates and pins is 78 tons, and four tons of wrought iron in bolts, &c. There are 5,600 cubic feet of timber work in the platform.

The bridge will have to stand a test moving load of 96 pounds per square foot, and will not give a greater strain on the steel chains than twelve tons per square inch, and the breaking strain of the steel is 36 tons per square inch. The links are being made at the Cyclops Steel and Ironworks, Sheffield, and the other work is being made

at Prague. The pier and anchorage and abutments are now complete, and the anchorage chains are in place. It is to be opened for traffic on the 1st of November of this year.

The design was made by Mr. R. M. Ordish, and is being executed by the same contractors who had built the Franz Joseph Bridge, viz., Messrs. Ruston & Co., Prague. Charles Von Wesseley is the resident engineer. The contract for the structure has been taken for £18,500.

THE METAL HYDROGEN.

Based on its chemical and physical properties, the opinion has long been held that hydrogen is a metallic element. Though only known to us in the form of a gas which has hitherto resisted all our endeavors, by pressure and cooling, to cause it to change its state of aggregation, and condense to a liquid or take a solid form, it cannot fail to be recognized that its existence in this condition only, depending as it does on the imperfection of our scientific instruments, in nowise invalidates the doctrine of its metallic nature. The attempts to condense hydrogen were unsuccessful on account of the difficulty of rendering vessels absolutely tight at such enormous pressures. Mercury, on the other hand, is liquid at ordinary temperatures; zinc, magnesium, and other metals are readily converted into gas, and gold and silver can be volatilised in the electric arc. Platinum, which Faraday melted in the flame of a candle, can doubtless be dissipated as vapor. The failure, therefore, to solidify hydrogen at present proves nothing.

The difficulty of condensing hydrogen has recently been attacked from another direction. About a year ago the Master of the Mint startled the scientific world with the announcement that he had extracted hydrogen from iron.

He placed a piece of the Lenarto meteorite in vacuo, and on subjecting it to heat drew from this iron several times its volume of hydrogen. This gas which, when free, so readily diffuses that it cannot be preserved for many days in a tube over mercury, but passes between the mercury and the walls of the tube and escapes into the air, was so firmly combined with the iron that, not the removal of atmospheric pressure alone, but the application of heat also, was required to effect their separation.

Recently Mr. Graham communicated to the Royal Society another paper on this interesting subject. He now employs a metal that absorbs hydrogen, as melted silver or platinum black does oxygen, or water ammonia. Palladium occludes from eight to nine hundred times its volume of hydrogen, and he regards the product as an alloy of palladium with the volatile metal hydrogen, in which the volatile character of the one metal is restrained by its chemical affinity for the other, but which owes its metallic characters to both. The alloy has a density considerable less than that of palladium, and he has been enabled to calculate that of the metal hydrogen, which he finds to be 1·951. Hydrogenium, as the new alloy is called, is more magnetic than palladium, in the ratio of 48 deg. to 10 deg., and must be considered to forsake "the class of paramagnetic metals, to take a place in the magnetic group of iron, nickel, cobalt and others." The occlusion of hydrogen by palladium reduces its tenacity and electric conducting power.

The strongly marked magnetic character of hydrogen, the readiness with which it forms alloys of such great permanence, and, more especially, its occurrence in combination with iron in meteoric masses, are facts of special interest at the present time, now that the spectroscope has revealed the existence of such enormous quantities of this element in our system.—*The Engineer.*

THE STRENGTH OF CORRUGATED IRON.

As a supplement to Mr. J. H. E. Hart's paper on this subject,* we publish the following letter by him to the "Bombay Builder":

Sir—Referring to experiments on the strength and stiffness of corrugated iron, published in your journal August, 1868, I have to suggest to your readers the following formula for the deflection of the material, obtained from equations in Professor Rankine's work. At page 328, article 303, of the third edition of "Applied Mechanics," is the general equation—

$$\sqrt{}_1' = \frac{n'' M'_o c^3}{E I_o} \quad \ldots\ldots (25)$$

for the "deflection of a beam under any load," in inches. In this formula $c = l$, or $\frac{l}{2}$, according as the beam is fixed at one end only, being unsupported at the other, or supported at both. Confining ourselves to the care of sheets supported at both ends, the above equation becomes—

* Van Nostrand's Magazine, Vol. I, No. 2, p. 129.

$$\sqrt{}'_1 = \frac{n'' M'_o l^2}{4 E I_o} \quad \ldots\ldots (26)$$

The values of M'_o are those already given for M in equations 10 and 11, at page 95 of Vol. IV. of this journal; n'' is a factor depending on the distribution of the load, and is, for beams loaded in the middle $= \frac{1}{3}$, and for beams loaded uniformly $= \frac{5}{12}$.

E is the modulus of elasticity of wrought iron in pounds; I_o, the moment of inertia of the cross section of the beam. We may, I think, adopt the value of I_o for the cross section of corrugated sheets obtained from the equations for the transverse strength of the material. The general equation for the moment of resistance of a beam (see "Applied Mechanics," article 294) is $\frac{f I^o}{Y}$, and the value of $y = m' h$; also, as for all symmetrical sections $m' = \frac{1}{2}$, therefore $Y = \frac{H}{2}$ whence the moment of resistance $= \frac{2 f I_o}{H}$

But, as already mentioned, the moment of resistance (see "Civil Engineering," page 543) for corrugated sheets is $\frac{4}{15} f h b t$, and this equals $\frac{2 f I_o}{H}$, whence

$$I_o = \frac{2}{15} h^2 b t. \quad \ldots\ldots (27)$$

and equation 26 becomes for corrugated iron generally

$$\sqrt{}'_1 = \frac{15 n'' M'_o l^2}{8 E h^2 b t}. \quad \ldots\ldots (28)$$

and for the following particular cases:—

SHEETS SUPPORTED AT ENDS.

For central loads, $\sqrt{}'_1 = \frac{W l^3}{6{\cdot}4 E h^2 b t}$. (29)

For distributed loads. . . . . $\sqrt{}'_1 = \frac{W l^3}{10{\cdot}24 E h^2 b t}$. (30)

E, the modulus of elasticity, may be deduced from the experiments under reference by the formula

$$E = \frac{W l^3}{6{\cdot}4 \sqrt{}_1 h^2 b t}. \quad \ldots\ldots (31)$$

which, using the data obtained, gives values for E ranging from 21,000,000 to 30,000,000, being, on the average, 25,000,000; or it may be taken from any of the published results on the elasticity of wrought iron. Thus, in Professor Rankine's work we find E = 29,000,000 for bar iron; also E = 24,000,000 as a "good average" for plates. For the case of sheets fixed at both ends the deflection is (article 307, "Applied Mechanics")—

$$\sqrt{}'_1 = \left(n'' - \frac{m''}{2}\right) \frac{M_o c^2}{E I_o}. \quad \ldots (32)$$

In this formula $m'' = \frac{1}{3}$ or $\frac{2}{3}$, according as the load is collected in the center or uniformly distributed; and in both cases the value of $n'' - \frac{m''}{2} = \frac{1}{12}$, also c^2 as before $= \frac{l^2}{4}$ and as the case may be; therefore equation 32 becomes,

IN SHEETS FIXED AT ENDS.

For central loads—

$$\sqrt{}'_1 \frac{W l^3}{192 E I_o} = \frac{W l^3}{25{\cdot}6 E h^2 b t}. \quad \ldots (33)$$

For uniformly distributed loads—

$$\sqrt{}'_1 \frac{W h^3}{384 E I_o} \frac{W h^3}{51{\cdot}2 E h^2 b t}. \quad \ldots (34)$$

Hence, it appears, sheets are made stiffer by fixing their ends, in the ratio 4 : 1 for central loads and 5 : 1 for uniformly distributed loads. We see from previous equations that they are made stronger in the ratio 2 : 1 and $1\frac{1}{2}$ to 1 respectively.

In calculating values of E from the experiments, it is advisable to reject the first weight and its deflection, basing the calculations on the difference between the first weight and deflections and those of a value of somewhere about one-third the breaking weight. The reason for this precaution is that any error due to the first settling of the sheets to their bearings may be eliminated from the result.

SAFETY OF STEAMSHIPS.—A correspondent of the London "Times" proposes to clear steamers of water entering by leakage or shipped in heavy weather, by means of steam jets arranged something like the Giffard injector, and worked with the full boiler power, if necessary, so as to discharge, say, 1,000 cubic yards of water per minute. It certainly seems unnecessary for a ship with 1,000 to 5,000 horse power, all in working condition, to founder for the want of means of application. The jet proposed would be simple and always ready to work. Centrifugal pumps would, perhaps, accomplish more, keep the ship afloat with a bigger hole in her, and might be kept always in order.

THE HERCULES IRON-CLAD.

REMARKABLE PERFORMANCE — PARTICULARS OF THE ENGINES, THE VESSEL AND THE TRIAL.

Compiled from "Engineering" and "The Engineer."

The attainment by an iron-clad frigate, at her deep-load draught, of a speed of 14.7 knots, or over seventeen miles per hour; and the development of 8,528 indicated horse power by a pair of marine engines weighing with their boilers, water, etc., complete, but 1,095 tons, are facts, the importance of which it is impossible to overrate. These results were obtained on January 1st, by the Hercules, and are extremely creditable to her designer, Mr. E. J. Reed, and especially so to Messrs. Penn, constructors of her engines.

DESCRIPTION OF THE VESSEL.—The Hercules is the latest, and the representative broadside ship of the British navy, and is of the following dimensions:

	ft.	in.
Length	325	0
Breadth	59	0
Draught forward	23	0
Draught aft	26	5
Tonnage	5,234 tons.	
Displacement	8,680 tons.	
Midship section	1,315 sqr. ft.	

Her armor consists of a belt of plating, extending from five feet below the water line to nine feet above it, this belt being surmounted by the central battery, whilst at the stem and stern are the armor-clad batteries in which the fore and aft guns are placed. At the water line the armor consists of nine inch plates, backed by 40 inch. of teak, whilst above this belt the thickness of the plates is reduced to eight inch. and six inch. The ends of the central battery are protected by six inch plates. The armament comprises eight eighteen ton guns, throwing 800 pound shot, placed in the central battery; a twelve ton gun, throwing 250 pound shot, mounted under the forecastle behind armor-clad ports; a similar gun, mounted in the captain's cabin, in an armor-clad stern battery; and four six and a half ton guns, throwing 115 pound shot, placed on the upper deck, and fought through unarmored ports. Of the eight eighteen ton guns, four can be fought through the ordinary side ports, the sills of which are eleven feet above the water line, whilst the other four can be fought from ports at the angles of the central battery, and can be fired within fifteen degrees of the centre line of the vessel. The twelve ton guns can be fired directly in the line of the keel, the one forward, and the other aft, whilst they have each also a considerable lateral range. Besides possessing a most powerful armament, the Hercules has been so constructed that she may be used for ramming purposes, and for such a method of attack her great handiness and high speed peculiarly fit her.

DESCRIPTION OF ENGINES.—These are trunk engines, by John Penn & Son. They are fitted with surface condensers, exposing 20,768 square feet of surface, the condensing water being supplied by a pair of centrifugal pumps, arranged so that they can be made to draw from the bilge, and capable of delivering 120 tons of water per minute. The circulating pumps are driven by a pair of independent engines.

Steam is supplied by eight boilers, having 40 furnaces, the fire-grate surface being 907 square feet, and the total heating surface 23,100 square feet, of which 19,792 square feet are tube surface. The boilers are fitted with eight superheaters, containing, in all, 3,908 square feet of surface.

Number of cylinders	2
Diameter of cylinders	127 in.
Diameter of trunks	47 in.
Effective diameter of cylinder	118 in.
Stroke	4 ft. 6 in.
Nominal horse power	1,200 H. P.
Load on safety valves	30 lb. per sq. in.
Temperature of steam in superheater from 305° to 310°.	

Propeller.		
	Description	Griffiths' varying pitch from 20 ft. 6 in. to 25 ft. 6 in.
	Diameter	23 ft. 6 in.
	Pitch	24 ft.
	Length	4 ft. 7 in. at root of blade, 1 ft. 3 in. at periphery of do.
	Immersion of upper edge	1 ft. 11¼ in.

Of the machinery of the Hercules, and of its performance, it is impossible for us to speak too highly. As specimens of excellent design, combined with the very best workmanship which even Messrs. Penn can produce—and their workmanship is certainly unsurpassed, and in but very few cases equalled—the engines of the Hercules stand unrivalled, whilst the power developed by them by very far exceeds that ever obtained on shipboard from any engines, under any circumstances whatever. Mr. Penn has long taken the lead in the adoption of high speeds of piston, and the success he has obtained has decisively shown the advantages of such speeds, when accompanied, as they should be, by first-class workmanship.

THE PERFORMANCE.—The trial at Stokes Bay, on Jannary 1, consisted of six runs over the measured mile, under full steam,

and four runs under half-boiler power, under the conditions of craft mentioned above, and with the following particulars of power, speed, etc.:

	Full power.	Half power.
Pressure of steam in boilers	29. 5 lb.	21.87 lb.
Vacuum in condensers for'd	27.08 in.	28. 5 in.
Vacuum in condensers aft	27.08 in.	28 in.
Number of revolutions max'm	72.00	58.52
Number of revolutions mean	71.51	55.29
Mean pressure in cylinders	20.00 lb.	12.268 lb.
Indicated horse power	8,528.75	4,044.91
Speed of vessel	14.691 knots.	12.122 knots.
Time under way	5 hrs. 25 min.	
Time at full speed without stopping	1 hr. 55 min.	
Weather barometer	30.20 in.	
Wind Force	2 to 4	
Wind Direction	S.W.	
State of sea	Smooth.	
Engines stopped from time of moving telegraph	19 sec.	
Engines started ahead from time of moving from astern	14 sec.	
Engines started astern from time of moving telegraph	16 sec.	
State of masts, yards, etc.	complete.	
Quantity of coals on board	600 tons, including 70 tons of trial coal.	
Armament	complete.	
Quantity of stores	six months'.	

	No. of runs.	Revolutions of engines per min.	Observed time.	Speed due to time.	First mean speeds.	Second mean speeds.
				knots.	knots.	knots.
Full power.	1	71.51	3.47	15.859	14.621	.....
	2	70 93	4.29	13.383	14.763	14.692
	3	71.31	3.43	16.143	14.617	14.690
	4	72.00	4.35	13.091	14.764	14.690
	5	71.78	3.39	16.438	14.624	14.694
	6	71.53	4.41	12.811	.....	.....
		71.51	Mean.	True mean speed.		14.691
Half power.	1	58.42	4.27	13.483	12.394	.....
	2	55.51	5.21	11.215	12.036	12.192
	3	54.00	4.40	12.857	12.071	12.053
	4	53.23	5.19	11.285	.....	.....
		55.29	Mean.	True mean speed.		12.122

The engines exerted rather more than seven times the nominal power. The importance of this fact will be brought into a stronger light by comparing the engine power and displacement of the Warrior, Bellerophon and Minotaur with those of the Hercules. In the official reports we find the following results:

WARRIOR.

Nominal H. P.	1,250
Indicated H. P.	5,092
Displacement in tons	9,214
Pitch of screw	30 ft.
Revolutions of screw	52.6

MINOTAUR.

Nominal H. P.	1,350
Indicated H. P.	6,193
Displacement in tons	10,275
Pitch of screw	25 ft.
Revolutions of screw	54.96

BELLEROPHON.

Nominal H. P.	1,000
Indicated H. P.	6,199
Displacement	7,369
Pitch of screw	20 ft. 1 in.
Revolutions of screw	73

HERCULES.

Nominal H. P.	1,200
Indicated H. P.	8,500
Displacement	8,610
Pitch of screw	24 ft.
Revolutions of screw	71.5

It will be seen from these figures that the Warrior has one horse power to every 1.8 tons of displacement nearly; the Minotaur has one horse power to 1.64 tons nearly; the Bellerophon has one horse power to 1.72 tons, and the Hercules one horse power to 1.01 tons nearly. To this vast excess of power is due the fact that the Hercules is faster than her larger rivals. Calculating from these data the co-efficients according to the usual formulæ, we get:

	Full boiler power.	Half boiler power.
$\frac{\text{Speed}^3 \times \text{mid sec.}}{\text{Ind. H. P.}}$	488	578
$\frac{\text{Speed}^3 \times \text{disp.}^{\frac{2}{3}}}{\text{Ind. H. P.}}$	157	186

It is difficult to compare the constants of the Hercules at her full speed with those of other ships, for no other iron-clad has yet steamed so fast at deep-load draught, and, as is well known, the increased speed obtained under such circumstances must be accompanied by a reduction of the constants. The half-power runs seem to show clearly that, for a short ship, her form is very good, as her half-power constants are higher than the Bellerophon's. The respective half-power constants are as follows:

Hercules.	Bellerophon. (at load draught)
578	543
186	171

the speed of the Bellerophon being, then, 12.154 knots, or almost exactly that of the Hercules under similar circumstances. The full-power constants of the Hercules fall below those of the Bellerophon, which vessel gave, on different occasions, when tried at load draught, the following constants: 518 and 163, 534 and 167, and 530 and 166. Considering, however, that, as we have already mentioned, the constants fall with an increase of speed—and especially at very high speeds—the Hercules has given

very good results, as the Bellerophon constants just given were obtained with speeds of 14.171 knots, 13.874 knots and 14.023 knots respectively, whilst the speed of the Hercules was, as we have seen, 14.691 knots. It must not be forgotten, however, that as the Hercules stows but 600 tons of coal, she cannot keep the sea at full speed for any time. Six hundred tons of coal are as nothing in comparison with 8,000 horse power or so. The consumption of fuel cannot be much less than fourteen tons per hour. Therefore, in round numbers, the Hercules carries coal enough to steam at full speed for forty-three hours only, or to carry her, assuming her to have a fourteen-knot sea speed, 602 knots only. In this respect she possesses the worst defects of the short iron-clad.

It is important to observe that the weight of the engines complete and of the boilers and water, is but 1,090 tons, or two and a half cwt. per indicated horse power, a weight which is wonderfully small under any circumstances, and particularly so when the size of the engines is considered. The proportions of areas of the heating surfaces, fire-grate surface, &c., to the power developed, are as follows:—

	Per indicated horse power.
Heating surface	2.7 sq. feet.
Fire-grate "	0 106 "
Superheater "	0.47 "
Condensing "	2.43 "

As to the handiness of the vessel, we have the following particulars. The balanced rudder first used on the monitors by Captain Ericsson, is employed.

Circles made Under Full Power.—Helm to starboard,—Angle of rudder, 40 deg.; turns of wheel, four. Half circle made in one min. 50 sec.; full ditto, four min. Men at the wheel, sixteen. Helm to port.—Angle of rudder, 38 deg.; turns of wheel, four. Half circle made in one min. 50 sec.; full ditto four min. Men at the wheel, sixteen. The diameter of the circle made in each instance was estimated at not more than twice and a half the ship's length.

Circles Under Half Boiler Power.—Helm to starboard.—Angle of rudder, 40 deg.; turns of wheel, four. Half circle made in two min. 21 sec.; full ditto, four min. 36 sec. Men at the wheel, sixteen. Helm to port.—Angle of rudder, 39 deg.; turns of wheel, four. Half circle made in two min. 40 sec.: full ditto, four min. 50 sec. Men at the wheel, sixteen.

CONCLUSIONS.—The British authorities conclude that no other navy in existence can boast of the possession of a ship at once so fast, so handy, so impregnable, so strong, or carrying so heavy an armament. The impregnability, the strength, the handiness, and the powerful armament of the ship are due to Mr. Reed, and he may well be satisfied with the honor which this fact does his reputation as a shipbuilder. But the great speed of the ship is due to Mr. John Penn, and it is only by the adoption of a high piston speed that such results could be obtained; and to such speeds, when combined with good design and workmanship, there is no objection whatever. All the expectations formed respecting her have been more than surpassed in the performance of her engines. The builders had counted upon a speed of 65 revolutions, and an indicated power six times the nominal, but so far were the results beyond these, that the engines averaged 71.51 revolutions, or 643.6 feet of piston per minute, and exerted 7.107 times their nominal power, or 8528.75 indicated, giving one indicated horse power to every 2.7 square feet of heating surface, a proportion seldom exceeded even in locomotive practice, with its quick draught and consequently rapid rate of combustion. Of course we are to admit that the runs were not of very long continuance, the coals were hand picked, and fired with little regard to economy, and the heating surfaces were clean. The indicator cards show not far from 25 lb. of water, or 0.4 cubic foot, for each indicated horse power at full speed, or about 3,411 cubic feet in all, being one cubic foot to about 6.77 square feet of surface, a high rate in marine practice, although often exceeded in locomotives. There are some forms of marine boilers—those, for instance, with water tubes—which show, according to Mr. Isherwood's experiments, but one cubic foot of evaporation for every 30 square feet of heating surface, the latter being in the case of the Merrimack, 12,537 square feet, while the steam discharged per hour into the condenser, the steam having been calculated from the indicator cards alone, was equal to but 403½ cubic feet. It is true that this was fourteen years ago, but the same class of boilers is still employed in the American navy.

STEEL RAILS.—Over 11,000 tons of steel rails are now in use on the Hudson River Railway.

RAILWAYS FOR CHINA.

From "Engineering."

Now that a through communication across the American continent, by means of the Pacific railway, is nearly completed, with a direct route to the chief Chinese ports, a fresh interest has been awakened as to engineering prospect in the Celestial Empire, and engineers are turning their attention so far eastward.

The principles upon which a railway system in China is established, must differ very widely from those which have governed the formation of lines in other new countries. For instance, in India there was a responsible government; throughout it were plentifully scattered the necessary elements for carrying out the undertaking—English energy and enterprise. Even less then than now, was the country burdened with official routine and red-tapeism. Shareholders were liberally guaranteed, and the rapid construction of railways were as necessary for military purposes as for the development of the country's natural resources. Preliminarily, there was only English opposition to conquer—no native prejudices to overcome.

In China, an entirely different moral aspect rules. From Imperial Majesty downwards, jealousy of foreign interference must take the place of hearty co-operation, and Imperial Celestial guarantees would scarcely satisfy capitalists who have had sore experience of European repudiation. The vital military necessity for rapid communication from one part of the country to another is not fully understood; and there exists the difficulty of overcoming national prejudices, which the effacing of the footsteps trodden by a hundred generations must inspire. The insecurity of Government guarantees, the jealousy of Imperial officials, and the prejudices of the people, are there, the principal difficulties to be encountered.

On the other hand, China possesses a vast undeveloped mineral wealth, and the monotonous industry of her 367,000,000, now put forth year by year, for the preservation of life, not for advancement; for the most part, the well-cultivated alluvial territories are level, and on these tracts the vast mass of the population is found, where labor is so cheap and abundant, and where the essentials for railway construction are most easily attainable. The enormous traffic now floated slowly and laboriously down the canals and rivers to the commercial centers would be transferred to the more rapid and cheaper mode of conveyance, and the introduction of railways would be followed by an invasion of western energy to the almost unworked fields which have been closed to the outer world for so many thousands of years.

The British residents in China agree with those missionaries, whose experience is invaluable, that the first experimental line should be made between Canton and Fatshan, a manufacturing town lying fifteen miles to the south of the larger city, and containing paper factories, gun foundries, and other industrial works; at present some half a million passengers are conveyed between the two places by passage boats, and the transit of merchandise is regular and heavy; this line could be completed in fifteen months. Far away to the north, another experimental line could well be made from Tientsin, the terminus of the grand canal, to Pekin, 70 miles distant, a railway which would secure all the traffic from the canal to the capital, and bring the advantages of a railway system under the immediate notice of the Imperial Government.

In sketching out his views as to the most favorable course for the trunk lines of China, Sir Macdonald Stephenson (who proposed a plan of railways for China in 1846) takes the town of Hankow, on the Yangtse-Kiang, as a commercial center, from which the railways would run east to Shanghai for 650 miles, south to Canton and Hong Kong for 850 miles, and north to Pekin for 800; westward the distance to India is 1600 miles. Shorter lines would connect Canton with Samshui, 40 miles distant, and would intercept the traffic now brought down the north and west rivers, at the junction of which Canton is situated. Between Hong-Kong and Canton, an extensive passenger traffic would be obtained by the construction of 90 miles of line. At present, passage boats and four American steamers meet the requirements of trade. Shanghai and Luchow are two important cities between which exists an enormous traffic that could be secured by the laying of 60 miles of railway through a level country. The line from Hankow to Canton, in passing through the Mieling range of hills, where the only engineering difficulties occur, would strike through extensive coal fields, 60 miles north of Canton,

and now worked only rudely, and near the surface.

This large and promising field for engineering will not lie much longer fallow. Anglo-Saxon enterprise will soon be at work in it, and it is reasonable to hope that native opposition will soon give way after the first railroad is opened.

THE LAKE CONSTANCE RAILWAY FERRY.

Compiled from "Engineering."

This ferry, for the transportation of merchandise trains, will connect the town of Friedrichshafen on the northeastern, with Romanshorn on the southwestern side of the lake, the distance across being about eight miles. Friedrichshafen is the terminal station of the Royal Wurtemburg States' railway, leading from Ulm, Stutgard and Frankfort. Romanshorn is the terminus of the Swiss Central railway, which runs to Zurich, Lucerne, Berne and Lausanne.

The vessel, which is constructed to carry twelve wagons, is 230 feet long on the railway deck, 40 feet beam, and six feet six inches deep from the top of the floor to the underside of the beams of the railway deck. Her tonnage is 1,753 tons, builders' measurement, and her draught of water does not exceed six feet. The hull of the vessel, together with the deck, deck houses, paddle boxes, paddle beams, and upper works generally, are of iron; and there is also an iron upper deck 80 feet long, placed at a height of about fourteen feet above the railway deck, so that it is clear of the carriages. The railway deck is provided with two lines of rails six feet apart, each line being capable of accommodating six wagons. The form of the vessel is the same at both ends, each end being fitted with a rudder provided with suitable stops. For a length of 100 feet amidships the vessel has a parallel body, and this part is built on the longitudinal principle, the framing consisting of longitudinal stringers two feet wide, with single angle-irons at top and bottom, and transverse frames two feet wide at the bottom and sides, and eighteen inches at the top, with single angle irons at the outer and inner edges. These latter frames are placed eight feet apart, except at the engine rooms, where they are spaced to suit the engines. The ends of the vessel beyond the parallel body are also built upon the longitudinal system as far as possible, but the extreme ends have frames of the usual kind. The outside plating of the hull is one-half inch, and the inside plating three-eighths inch thick, whilst the angle-irons are throughout three and one-half inches by three and one-half inches by one-half inch.

The vessel is divided by transverse bulkheads into nine water-tight compartments, the central compartment being thirty-two feet long, whilst six others are each twenty-four feet long, leaving the end compartments to make up the remainder of the length. In the central compartment are placed the engines, as we shall explain presently, while in the two next compartments, one forward and one aft of it, are situated the boilers and coal bunkers. Besides the transverse bulkheads there are two longitudinal bulkheads, which are placed twenty-two feet apart, and which extend the whole distance between the extreme transverse bulkheads. The railway deck is made of plates planed at the edges and butt jointed, and it is carried by transverse beams eighteen inches deep, and placed eight feet apart, these beams being firmly rivetted to the skin, and being each supported at the center by a hollow wrought-iron column fixed to the floor plates. Four longitudinal beams, eighteen inches deep, also assist in stiffening the railway deck, these beams being placed immediately beneath the lines of rails.

The engines are of 200 horse power nominal, and consist of two independent pairs arranged one on each side of the vessel, in the spaces which are divided from the central part of the longitudinal bulkheads. Each pair of engines consists of two oscillating cylinders inclined so as to form an angle of 90 degrees with each other, these cylinders being three feet four inches in diameter with six feet stroke. The centers of the cylinders are in line, the two piston rods being coupled to one crank pin. The engines are fitted with the link motion for reversing, and are also provided with separate expansion gear. The cranks are overhung, there being one frame in each engine-room supported by a pair of columns, while the outer ends of the shafts are carried by the paddle beams. The paddle wheels are twenty-four feet in diameter, and have each twenty-four fixed floats; and as each wheel its driven by its independent pair of engines the two wheels can be run in opposite directions to facilitate turning the vessel if required.

In the space between the two pairs of engines is placed an auxiliary engine which

drives one of Gwynne's centrifugal pumps, and also the four capstans of the ship. There are four boilers, two to each pair of engines, and they are placed close to the sides of the vessel, the one pair forward and and the other pair aft of the engines to which they respectively belong. The coal bunkers are also placed close to the sides of the vessel, the one forward and the other aft of the engines, each bunker being thus on the opposite side of the ship to the boiler which it supplies. By the arrangement of boilers above described, the funnels are brought to the sides of the vessel clear of the railway trains. The boilers are worked at a pressure of twenty-eight pounds per square inch.

As the water level in Lake Constance varies somewhat at different seasons, and as the vessel is of course liable to fluctuations of load, it may be required on some occasions to lower either end of the vessel to facilitate the embarkation or debarkation of the wagons. For this purpose the compartments between the two extreme bulkheads at each end are not only made watertight but are well stayed, so that they serve as water holds. Cocks and pipes connected with the pumps driven by the auxiliary engine enable these compartments to be filled with water and emptied at pleasure; and by filling one of them more or less, the end of the vessel to which it belongs can be sunk as required.

The designs and specifications for the ferry boat we have described, were prepared by Mr. J. Scott Russell, who is the engineer to the undertaking. The boat and engines were built by Messrs. Escher, Wyss & Co., of Zurich, the engines being designed by Mr. Murray Jackson, who was at the time manager to the above mentioned firm, but who is now engineer-in-chief to the Danube Imperial and Royal Steam Navigation Company. From some delay which has occurred, the ferry has not yet commenced running, but it is expected to start soon, and there is no doubt that it will be a success.

HEAVY RAILS.—The plan of Mr. Brunlees, for the new railway from London to Brighton (although it is to be a "cheap" railway, involves the use of steel rails of over 100 lb. to the yard, so as to have a head of the width of the tread of the wheels, and to distribute the weight of the rolling stock so as to obtain less than the present weight per wheel, and thus preserve the way.

TRACTION ENGINES IN FRANCE.

RESULTS OF EXPERIMENTS — THE ENGINES IN THE EXPOSITION. BY MONS. D. SIENARD.

Translated from "Annales du Génie Civil."

The problem of steam traction on common roads has been considered for a long time, even before the invention of railways; but not until within a few years has it begun to receive a practical solution. The road locomotive seems naturally called to fill the interval necessarily left in our system of railways; and it also offers important resources to certain industries which, like the beet sugar manufacture in particular, require much local transportation. It is, therefore, a question wholly practical; and although I am not prepared to treat it fully, I think it will be interesting to state the result of experiments which I have had occasion to follow up in the department de l'Aisne, on two road locomotives, the one of English manufacture, the other from the works of Mons. Albaret of Liancourt.

Mons. Albaret, in the arrangement of his machine, has not departed widely from the type of the railway locomotive. The boiler is composed of a cylindrical fire-box, and a horizontal barrel traversed by tubes, and is fed by a Giffard injector; and the heating surface is about 172 square feet. As the engine is to go on steep grades, it was necessary to provide against the inconveniences of changes in the water level. This difficulty has been happily solved. The horizontal barrel is full of water; and the steam formed in it while going up hill is received in a small dome on the forward end, and carried thence by an exterior pipe to the main dome over the fire-box; and the crown-sheet of the fire-box, instead of being flat, is hemispherical, and therefore always covered by an equal depth of water, whatever the inclination of the road.

The motive apparatus is composed of two cylinders, with link-valve gear placed under the boiler, and protected from dust by sheet-iron coverings, easily removed for oiling and cleaning. The crank-shaft transmits the motion by gearing to an intermediate shaft close in front of the fire-box, and on a level with the driving axle; and from this shaft the power is transmitted by an endless chain to the axle which is behind the fire-box. The driving wheels can be loosened or fixed to the axle by bolts, but not without stopping the engine. I do not know whether

others have, in a practical manner, fastened and loosened the wheels while in motion; but this is one of the points which ought to have the attention of mechanicians. The machine cannot turn conveniently without one wheel loose; and so long as the fixing and loosing cannot be effected while in motion, it will be almost necessary to work with one wheel loose, thus using only half the force which the machine might exert.

Road locomotives not being guided by rails, it is necessary that their front axles should be turned to the right or left. It is in this part that they differ most from each other. In the arrangement of Mons. Albaret, the front axle wheels are in advance of the smoke-box. To the middle of the axle is jointed an upright spindle, which turns in a socket that is held by a prolongation of the upper part of the smoke-box—the prolongation being high enough to allow the wheels 54 inches high, to turn under it, like the wheels of a common coach. The spindle is worked by an endless screw turned by a hand crank, gearing into a worm wheel on the upper end of the spindle. The shaft of the screw is prolonged to the foot-plate, so that the engineman can steer; and in this respect it has an advantage over other engines, which require special men to steer. This arrangement is important; because, independently of the saving of the wages of a steersman, it renders the maneuvering much more easy and certain. The machine is mounted on springs to soften the effects of jarring and jolting. In front there is a conical spiral spring around the spindle; and the hind springs are of the common laminated kind. The total weight is about ten tons, of which six and a half are on the drivers, which are five feet high and fourteen inches wide at the rims. The usual speed is five kilometres an hour, and the highest speed allowed is seven kilometres, (about three and one-third and four and one-third miles).

After being exhibited at the competition at Laon, in 1866, this engine was bought by Mons. Godin-Lemaire, to draw coal and iron for his foundry at Guise (Aisne). It worked between Guise and the fort of Longchamps a distance of four kilometres (two and two-third miles). It went out lightly loaded, and returned with a useful load of 15,000 kilogrammes (about fifteen tons), and burns at the maximum 250 kilos (550 lbs.), of coal per round trip. At these rates the daily expenses are less than half the cost of horse power.

Mons. Godin-Lemaire is, nevertheless, little satisfied with the results of his experiment—for it is not enough that the current expenses be reduced; it is necessary moreover that the machine shall be exempt from frequent derangements and important repairs. Unfortunately this locomotive leaves something to be desired in this respect. In the first place there have been and still occur, numerous leaks at the tube joints. These may be due to bad original construction; but it is to be feared that the suspension of the boiler is not without influence in this evil. The boiler is suspended at its ends, the axles nearly fourteen feet apart, and the jolts may cause strains very prejudicial to the joints. In the second place, the endless chains that transmit the power from the intermediate shaft to the driving axle have been found too weak; and the links and the teeth of the pinions have been much worn, and there have been many ruptures of them. Moreover the chains have been elongated—and not being sufficiently guided they have sometimes got outside the teeth, under the effects of violent lurches. Attempts have been made to mitigate the effects of the lengthening of the chain, by applying a tension rod, and making the pillow blocks of the intermediate shaft adjustable; but it is clear that the most efficacious remedy would be in the use of a chain so strong that the elongation would be insignificant; for, in spite of the two expedients above stated, there was produced such a difference between the relative pitch of the chain and the wheels, that they could not work together without a series of small shocks.

However these points may be, Mons Godin-Lemaire seems convinced that the transmission by chain is, in itself, bad; and that the road locomotive cannot become really practicable and capable of regular service, until the chain is superseded. I do not know whether the future will confirm this opinion; but I will remark that the experiments have been made under disadvantages, as Mons. Godin-Lemaire himself was the first to point out. In fact, the Longchamps route, which leads also to Bohain, is the one on which is performed nearly all the traffic of the industrial establishments of Guise. It is extremely worn, even to such extent that the merchandise brought from the north by railway has to be loaded at St. Quentin instead of Bohain. From this fact it will be understood that the route is very

ill prepared to receive the road locomotive; that the machine was exposed to numerous chances of accident which it would not have met in ordinary practice; and that we cannot accept as definite the condemnation of a system, on the results of an experiment made under such unfavorable conditions.

The other experiment, of which I shall now speak, has given more satisfactory results. Mr. Pilter, an English mechanician, instead of copying the railway locomotive, has limited himself to adopting an ordinary portable engine, and establishing a connection between the crank-shaft and the driving axle, by means of an intermediate shaft and an endless chain, as in the French engine. The engine is placed on the boiler; the fly-wheel is retained; and by ungearing the intermediate shaft, the locomotive may be made to work as a portable engine. It is therefore particularly convenient for agriculturists. The boiler is a plain cylinder and fire-box, without dome, and has 203 feet of heating surface. No special precaution has been taken to prevent changes of the water level on hills; and only a fusible plug is put in the crown-sheet, to cause the fire to be extinguished by a jet of steam in case the crown-sheet should become dry and hot. It is fed by a pump which can be worked while the engine is standing, by ungearing the intermediate shaft. The driving-wheels are 64 inches in diameter, and sixteen inches width of rim. As in Albaret's engine, they are fastened and loosened by bolts; but in the French machine the fastening is possible in any position in which the engine can stop; while in the English it is necessary to bring the wheels to one position on the axle, so that the holes may be in line. The front swivelling train is very complex. It has three wheels; the hind axle under the fire-box, held to it by a swiveling joint. The steersman sits with his back to the smoke-box, and by a tiller turns the front wheel as it is turned in toy carriages. The system works perfectly in forward motion; but in maneuvering and in untrained hands there is likely to be a misunderstanding between the engineman and the steersman which may involve much loss of time, if not more serious consequences. The total weight, and the distribution of it on the axles, is about the same as in the French engine—and the ordinary speed is the same, three and one-third miles an hour.

This is the engine which, in October, '67, made the experiments of towing boats on the Oise, of which all the journals have spoken. It was thence taken to the sugar manufactory at Braisners, near Soissons, where Mons. Duffié proposed to use it for the transportation of beets. It worked for about 40 days between the factory and a depot at Cuiry-Housse, eight kilometres distant. The road is in very good condi tion, but its profile was very accidental, for it has barely two kilometres of level, and the rest is in steep hills and inclines varying from three to seven in 100. Its ordinary train was two large wagons, each containing 7.4 tons of beets. On the return trip it drew five to six tons of pulp. It made two round trips per day, and burnt 1,540 to 1,760 lbs. of coal. In going and returning the tank was filled with water by means of hose from a pond six kilometres from the factory; and in addition, to provide for emergencies, the train was always followed by a cask on a cart containing from two to three hectolitres of water. In dry weather the traction was easy, but in wet and muddy weather there was such slipping as to show the necessity of lightening the loads or roughening the wheels. Notwithstanding the regulations against rough wheels, the administration, for the sake of rendering the experiment conclusive in all respects, made no opposition, and Mons. Duffié applied on the tires of the driving wheels strips of plate iron 1.2 inches wide by 0.4 inches thick and 24 inches apart (eight on the entire circumference). With this addition the machine drew its load over the hills, and was no farther hindered in its work until the time of ice and fresh snow.

The service of this machine was generally satisfactory during the winter of 1867–8. This is not to say that it always avoided accidents, and that there were no ameliorations to be desired. Far from it. As the fusible plug corroded, it had to be replaced every week, although it had never been left completely uncovered. The chain, though stronger than that of Albaret, has had several links broken, and at the end of the season it had to be replaced. There have been some ruptures of teeth; and, at the outset, before the men had become expert, the complication of the swivelling train or three-wheel bogie occasioned some accidents during its maneuvers, such as getting into the ditches of the road, from which the machine could not always extricate itself. But these are accidents inevitable in the beginning of a new system, and Mons. Duffié, recogniz-

ing that his apparatus is far from having attained its ultimate perfection, does not hesitate to regard this machine, even in its present state, as capable of practical use, and of rendering important service to industry.

We will say a few words about cost.

Mons. Duffié generally sent four men with his convoy—three on the engine and one behind to look out for the train and hold the horses that were met, and aid the measurers at the beet depot. The wages of these men was 13 francs per day. The coal cost 21 francs (at 28 fr. per ton), and the oil cost four francs. In all, 38 francs per day to transport 40 tons of beets or pulp eight kilometres. The cost of haulage therefore amounted to .119 fr. per ton per kilometre. As to the general expenses, they are difficult to estimate, for they depend on the number of days of work in the year and the importance of the repairs of the machine. Mons. Duffié hopes to use the engine 100 days in the year, 50 in winter for transporting beets, and 50 in summer for supplying coal and for working in cultivation. The engine cost 14,000 francs, and six wagons at 1,000 francs each, makes 20,000 francs for the cost of his material. Allowing 20 per cent for interest and decay, the engine being estimated to last six years, and adding 1,000 francs per year for repairs, we have a yearly expense of 5,000 francs, which distributed over the work of the 100 days gives .156 francs per ton per kilometre. The total cost, therefore, is .275 francs. At this rate, Mons. Duffié has already realized some economy, for the transport of beets by the wagoners has never cost him less than .3 francs, and it has often cost more in unfavorable seasons.

These costs have been very largely estimated, and in many cases they may be much reduced. The consumption of coal has been enormous, nearly 24 kilogrammes per kilometre, which is just twice what the constructors state in their advertisements, but without reckoning the lighting of the fires. This excess arises from two causes. First, from the profile of the road, whose grades considerably augment the resistance to traction. Second, the season in which the work was done, for the resistance to rolling varies much in consequence of the dryness or wetness of the road. When the road was frozen they have been able to make three round trips in a day, and then the consumption of coal did not exceed 950 kilogrammes; that is, less than 20 kilogrammes per kilometre. We may therefore admit that in a fine season, and on a route with good grades, the consumption would not exceed sixteen or eighteen kilogrammes, and the price would then be lowered .02 per ton per kilometre. Besides, I have supposed only 100 days' work in a year, while the machine could easily work 250 days and leave time enough for cleaning and repairs. Computing in this case the decay at 30 per cent and the repairs at 1,500 francs, the general cost would be lessened at least one franc per ton per kilometre. Finally, Mons. Duffié's engine worked but 32 kilometres daily, when it could have worked 40 or more, and, in effect, it did but a third of the work of which it was capable. I think, then, that it may be concluded, from the experiments at Braisne, that in the present state of the engines they can transport at .2 francs per ton per kilometre, provided they have work enough to keep them fully employed, and to attain this result it will suffice to have 400 tons of transportation to do during 250 days in the year. This amount of work could, at the most, supply a railway only two kilometres long.

In what precedes I have occupied myself only with the machines. I have endeavored to show the results already attained and to indicate the improvements which had to be realized. I cannot pretend to have succeeded fully, since I have had occasion to examine only two types of road engine, both exclusively for freight. But in the organization of a system of steam traction it is necessary also to think of the embarrassment of the travel already existing on the roads and of the effect of the new system on the preservation of the roads. In these relations the experiments at Guise and Braisne are conclusive. The locomotive obeys with the greatest docility the direction of its conductor, and easily makes way for other vehicles to pass; but, owing to its great weight, it does not always do this without danger to itself, when the roads are narrow and the sidings are very soft. In such case it cannot always cede half the road, as required by regulations, without difficulty to itself. Horses soon accustom themselves to the noise of the machine, and after a few trips they pass without more alarm than they show in passing common vehicles. Still, with pleasure horses that are more spirited than work horses, precautions are taken; but these horses are not frequently met.

Finally, the locomotives, with their broad wheels, heavily loaded, serve as road rollers, and seem to have only good effects on macadam. The front wheels being nearer together than the drivers, a considerable part of the road is rolled and there is no tendency to form ruts. At Guise, as at Braisne, it was remarked that the road was injured only by the wagons, whose wheels were not wide in proportion to their loads. It will be easy to build wagons with wider wheels and the front wheels nearer together than the hind wheels as in the locomotives, so that the steam trains may have the best effect on roads.

By the regulations made for road locomotives, their tires must be smooth, without any projection. It was feared that if otherwise, they might break up the surface and seriously impair the durability of roads. But the trial of Mons. Duffié showed that these fears were unfounded. I was at Brisne after several days of rain. On the road there were some parts dry, others moist and soft, and others covered with mud. On the dry parts the holding strips left slight traces; on the soft parts there were mere impressions of the strips; and only in the mud, where the foot would leave a track, was there any tearing up; and this did not extend below the stratum of mud nor affect the macadamising. And even this slightly injurious effect would not have been produced had the strips been put near together, instead of two feet apart. With this distance apart it often happened that no strip had held, and there was slipping, and the next strip arrived at considerable speed, striking a blow which tore up the ground. Yet at the end of the year this road was not more worn than at the end of previous years, and Mons. Duffié had no increased road taxes to pay. And I am persuaded that the interdiction of holding strips will be removed, since they are allowed in England, where road engines have come much into use. I will add that, in my opinion, this is a condition indispensable to the general use of steam traction, for the load that can be drawn with smooth tires is too limited, the force of the machine not well utilised, the dead weight too considerable, and the transportation cannot be performed with full economy. And were it true, which I think is not, that the projecting strips injured the roads, their use should nevertheless be permitted; for the State and the Departments, in providing for the repairs, would only have to lay just taxes on the new engines, which they could pay, and still work with advantage.

The Exhibition of '67 in the Champ de Mars brought together nine road locomotives, from four French and five English constructors. The English seem not to have thought seriously of applying them to the transportation of passengers, for their machines are adapted to draw heavy loads at relatively low speed—seven or eight kilometres at most. But in France the inventors have schemed to carry both passengers and goods. The locomotive of Mons. Larmanjat can draw only three tons, but its speed is sixteen to eighteen kilometres per hour, which is practicable only for passengers. Mons. Lotz, of Nantes, has aimed to construct a machine suitable for both services. The other French constructors, like the English, propose to carry only merchandise.

Before examining each machine particularly, I will glance at the whole together, to set forth the general characteristics adopted by their constructors.

Boilers.—Besides the conditions common to all boilers, there are two specially necessary to be considered in boilers for road locomotives. First, they must be made so that the fire-box crown-sheets shall remain covered with water while going up hills. Second, the form of the boiler should permit a firm and accessible arrangement of the organs of motion. The English have all adopted the same kind of boiler—the locomotive without a steam dome. This allows great latitude in the arrangement of the engines, on top or underneath. The danger of burning the crown-sheet is guarded against by a fusible plug, which will melt and allow steam to extinguish the fire before an explosion can occur. This system is simple, but it cuts the knot rather than unties it, and it may have the inconvenience of supplying moist steam, for want of a high and copious reservoir.

The French have been more inventive. The design of Mons. Albaret we have described. That of Mons. Larmanjat is analogous to it Mons. Calla's has also a dome over the fire-box and a barrel long enough to accommodate the motive mechanism. But the most radical solution is given by Mons. Lotz, who completely separates the boiler from the engines The boiler is upright and behind the driving axle, and the engine is inverted and attached to the tank, which is

placed forward at the distance suitable for the gearing and chain. The two conditions which I have stated are perfectly fulfilled, but it is to be feared that the boiler will be found too small for the speed proposed. On the whole, I think the English type is really the most practical.

MOTIVE MECHANISM.—The first question is, whether there should be one or two cylinders. With two the motion is more equable, and there are no dead points. With one the construction is cheaper, and the maximum effort greater. This last advantage is not to be disdained in a machine which is liable to get mired, and to require for a moment a strong exertion of force. On this question opinions are divided, and of the nine engines, four (three of which are French), have two cylinders. The English have all put their cylinders on top of the boiler, near the chimney. Calla has put his cylinders on top, but near the fire-box. Albaret and Larmanjat place theirs under the boiler, where the mechanism is least accessible and most exposed to dust; but they have endeavored to exclude dust by coverings. And Lotz has placed his cylinder vertically over its shaft, in the forward part of the vehicle. This disposition is perhaps objectionable on account of the disturbance by the up-and-down movement of the piston.

MODE OF TRANSMISSION OF THE MOTION.—I have already spoken of the inconveniences of chains for transmitting motion from the intermediate shaft to the driving-wheels. Nevertheless, there are but three English constructors who have completely abandoned that system. Whatever be the mode of transmission, nearly all the machines can vary the number of turns of the engine to one turn of the wheels. Those of Albaret and Pilter are the exceptions. The others, excepting Lotz and Larmanjat, who aim to carry passengers, in their devices to vary the speed, have no other object than to save time when going without loads. All the French engines are on springs, and this is evidently advantageous on account of durability; but none of the English have deemed it useful to adopt this refinement. All the French engines have smooth driving-wheels, as required by the regulations. The English restrict themselves to this condition only in engines which they hope to sell in France.

STEERING APPARATUS.—For the swivelling of the front axle or truck there are as many plans as there are constructors. Of the nine machines five are steered by a special conductor placed in front; the four others are steered by the engineman. In going forward the first system evidently gives most safety; and it appears to me best for passenger carriages; but it is more costly, and renders maneuvering more complex, in consequence of want of perfect understanding between the engineman and steersman. I now pass to the examination of the different models separately, commencing with the English.

PILTER'S ENGINE.—Having shown the general arrangement of this machine, I shall here consider only some details of construction. The intermediate shaft, between the crank-shaft and the driving axle, is not placed high enough to pass over the top of the boiler; it therefore has but one bearing, and its working end overhangs. This disposition is unsatisfactory, and it is not surprising that several ruptures of the pillow-block occurred on the machine belonging to Mons. Duffié. On Pilter's locomotive, in the Exhibition, the motion is transmitted by wheels with conical surfaces, which work against each other, depending on friction. This system has the advantage of easy connection and disconnection while in motion; but it may be questioned whether, in practice, this kind of frictional gearing will have sufficient adhesion.

AVELING & PORTER'S MACHINE.—This has the same disposition as that of Pilter's, which is but a copy of it; for Aveling invented the three-wheel truck.* The intermediate shaft is not over-hung, as in Pilter's, but is placed high enough to pass over the boiler, and have a bearing each side. This shaft and the crank-shaft carry gear wheels at both ends, with different proportions, so that the speed may be varied by throwing either the right or left into gear. As in Mons. Duffié's machine, the fixing of the wheels is by bolts. Experience proves that when the tires are smooth, the fixing can be effected very well while in motion When one wheel is fixed and the other loose, the former slips a little, and soon brings the holes into line, so that the bolt can be pushed home; and this happens the sooner when the slipping is greatest, and there is

* We translate without comment. Our readers may know that this is older than Aveling; and on other points they may see that we might have corrected the author; but we deem it best to reserve our criticisms until we have occasion to write an original article on this subject.

most need of the adhesion of both wheels. The loosening is not practicable without stopping, for the bolt is held too strongly to be withdrawn while the power is exerted upon it. Porter's steering gear certainly requires the least effort of the steersman of any that I have seen. In maneuvering it requires a certain degree of expertness; but even in this view it is not inferior to the other systems that require a special steersman. Messrs. Aveling & Porter had two locomotives in the Exhibition, for which they received a medal. One, of six horse power, was bought by Mons. Schutman, of Don, to tow boats on canals. The other was of twelve horse power. They have engines now at work at the sugar factories in Nesles (Somme), in Barbiere (Oise), and in Moncornet (Aisne).

Machine of Clayton, Shuttleworth & Co. (Medal of the Exhibition)—It has two cylinders under the boiler. The transmission of the motion is by spur-gearing on two intermediate shafts; one of them over-hanging, like Pilter's. They say, in their prospectus, that their engine can turn curves of the shortest radius, being enabled by differential gearing of their own invention. I could not see this mechanism, as the attendant of their machine covered it when he saw that I was studying it closely. It has two steering wheels and a steersman in front.

Ransome's Machine.—This has one cylinder on the boiler near the chimney. The motion is transmitted by spur-gearing on two intermediate shafts, one of which is used only for slow motion. The fixing of the wheels is by friction clutches; but it is not effected while in motion. It has two steering wheels, and the smoke-box rests on the centre of the axle. Chains go from the ends of the axle to a horizontal wheel behind the engineman, who steers.

Underhill's Machine.—This has one cylinder. The motion is transmitted by spur-gearing. The fixing of the wheels is by bolts, as in Pilter's. It has two steering-wheels, with the load on the middle of the axle, as in Ransome's. A strong rod, jointed to one end of the axle, goes to the foot plate, where it is formed into a rack, and pushed or pulled by a pinion worked by the engineman. What strikes us in this machine is the extraordinary form of the driving-wheels, whose rims are of wood, with iron tires zigzagged, so as to leave on the ground a track similar to one represented by the figure 6. This system may give adhesion; but it may be feared that it will fail to give strength. For the rest, the constructors seem to have aimed to make portable engines that could propel themselves from place to place, rather than traction engines, for they have not provided coal boxes.

Larmanjat's Machine. (Medal of the Exhibition.)—It is of three horse-power, and expressly for passengers, and can draw three tons. Its centre of gravity is very low, which gives it great stability. It has two cylinders under the smoke-box turning a crank-shaft under the fire-box. This shaft acts by gearing on the driving axle. Behind the driving axle is a shorter axle, with smaller wheels, and an endless chain transmits the motion from one axle to the other. By levers, worked by screws, the smaller wheels may be made to carry the load, or may be lifted clear of the ground,—the wheels that are not carrying continuing to turn. When on a level the large wheels carry and run at sixteen to eighteen kilometres an hour; and on hills the small wheels carry at seven to eight kilometres. The higher speed is ten to eleven and a quarter, and the lower is four and three-eights to five miles per hour. This combination seems capable of working well; but evidently it is inapplicable to a heavy engine, and could not be used for a locomotive that draws heavy loads. It is steered by one wheel, held by a forked spindle, on the top of which is an arm, to which is jointed a rod worked by a pinion, by the engineman.

Lotz's Machine.—In external appearance this machine differs entirely from the others, which all more or less resemble railway locomotives or portable engines. In this all the organs are placed on a sheet-iron body with three wheels. Behind the driving axle is an upright boiler, and in front is the engine. The cylinder is vertical. The crank-shaft and two intermediate shafts are on a level with the platform. The motion is transmitted to the drivers by an endless chain. Gearings of different proportions, with clutches, enable the machine to be worked at three rates of speed. This complete separation of the boiler from the machinery has the great advantage of rendering repairs easy; and the engineman has all parts in sight and accessible. But, as I have said, the boiler appears too small. The driving axle has springs and axle boxes like those on railways. The fixing of the wheels

is by a brake, analogous to that in Ransome's. The axle of the steering wheel is fixed in a horizontal wheel with teeth on its rim, into which a pinion works, and a special steersman works the pinion. Lotz's engine has been bought by the director of the glass-works of Folembray (Aisne), and has worked since November, 1867, between Coucy and Chauny, transporting materials and products. Several other similar machines work at Orleans and at the mines of Blanzy.

ALBARET'S MACHINE.—Save, in a few details, Albaret's machine in the Exhibition is like the one we have reported. The endless chains are made stronger; and this is the only one that has a chain to each driving wheel.

COLLA'S MACHINE.—It has a framing like a locomotive, formed of two long plates with proper connections. This is an improvement; for it bears the shocks and strains which in the English and Albaret's engines are thrown upon the boiler. It has a steam dome over the fire-box, and a barrel long enough to receive the engines. The cylinders are on top, near the fire-box, and the crank shaft forward, and the intermediate shaft further forward, close to the chimney. With this arrangement the endless chain has to be very long, though the driving axle is before the fire-box; and the lengthening of the chain must therefore be more sensible. There are two steering wheels in front of the smoke-box, under the frame plates. The axle is connected to a horizontal wheel with a toothed rim, into which a pinion gears; and the pinion is turned by a band wheel worked by a special steersman. The drivers are fixed and loosened by clutches, which are worked while the engine is in motion. In the other engines the steersman in front has only to steer. In this he has to work the clutches which fix the wheels, and also to work the levers which change the rates of speed. The engineman has charge of the throttle, the reversing lever and the fire. Experience only can show whether this division of functions, between men so far apart, is the most advantageous. Under the seat of the conductor is a shaft worked by a chain, which in case of accident will serve to warp the machine forward, by winding a chain or rope that is fastened to an anchor or other fixed object ahead. This engine is solidly built; all its parts have been well studied; and all the difficulties have been noticed. But there is another side: on account of the steam dome the boiler has been made long to give room for the mechanism. The necessary organs are numerous, and augment the weight; and as the division of the weight between the axles is very unequal, because of the driving axle being before the fire-box, the weight on the drivers is excessive, twelve tons at least. This weight far exceeds the regulations; and there are few routes on which such a heavy engine could work safely.

I conclude this rapid review by saying that I entirely agree with the international jury who awarded the first premium to Messrs. Aveling & Porter. Their machine is the one which, by its simplicity and good construction, seems for the present to offer the best assurance of efficient and regular service on common roads.

ENGINEERING IN INDIA.—From a comprehensive article in the Calcutta "Engineers' Journal," we learn that the Government has fully sanctioned the establishment of the best schemes of irrigation and navigation throughout this vast industrial empire. Among the schemes for irrigation, surveyed and to be commenced, are the construction of 16 reservoirs in the Midnapore district, from which some 75,000 acres of land may be watered; also a canal for navigation and irrigation, from the Damoodah to Calcutta, 100 miles (already commenced); a system of canals from the Gunduck for the benefit of the districts of Chumparan, Sarun, and Tirhoot, and a canal from the Ganges at Rajmahal to Calcutta, also the Sutlej canal in Punjab—all these canals being designed to prevent the horrors of famine heretofore prevalent, and being adapted to navigation.

An Imperial sanitary commission has been appointed. One of its chief duties is to detect the cause of disease as arising from drainage, water supply, and ventilation. Simultaneously with this office the Government of India has made the appointment of an experienced mining engineer in connection with the geological survey of India, for the purpose of determining with precision the mineral resources of India, improving and extending mining operations, and subsequently collecting and tabulating the mineral statistics of the country, which has been looked upon with great pleasure and satisfaction by the country at large.

THE "UNIVERSAL" ROLLING MILL.

In an article on the progress of the British iron trade, "The Engineer" says: There is no one practically connected with the iron trade who is not tolerably familiar with what, by the use of the universal mill, Messrs. Petin, Gaudet & Co., for example (in France), have been able to accomplish. Their famous rolled beam 39⅜ inches in depth, exceeding 32 feet, in length, and weighing two and a half tons, with also their more than two-ton beam, upwards of a foot in height, and above 106 feet in length, in the Paris Exposition, evidenced the capabilities of the the universal mill.

The mill, as laid down at Messrs. Petin, Gaudet & Co.'s works, is not remarkable for novelty, for its essential features are to be found elsewhere, and Mr. Abram S. Hewett claims that they were embraced in the first train for rolling beams erected in 1853 at the Trenton works, New Jersey. Whilst the universal mill is by no means unknown to many of our readers, they may nevertheless feel interested in reading the description of it as given by the intelligent American ironmaster and United States commissioner we have named. He says that "for each size of beam there is a pair of rolls, each having a working face at the middle of its length equal in width to the depth of the beam. The diameter of the roll at this part is very large, say three feet six inches, the body of the roll for the rest of its length being about 22 inches in diameter. This formation of the rolls leaves a considerable space between the two, except where the working faces come together. In this open space is placed a pair of rollers working on vertical axes fixed in stout movable frames, by which they can be brought into juxtaposition with that portion of the horizontal rolls which is of largest diameter. The pile used is somewhat thinner than the width of the flange to be produced, and of a width somewhat greater than the depth of the beam, and is so made up as to conform roughly to the final shape of the girder. As the main rolls are brought together and form the trough in the beam, the friction rollers at the sides are also pressed towards the centre, and tend by the pressure which they exert to extend the flanges at the same time that the web is being drawn out by the main rolls. An offset is turned in the side of the large portion of the rolls to receive and form properly the flange as it is extended by the pressure of the friction rolls. The latter are worked each by a screw in a horizontal frame bolted to the side of the housing, the screw being provided with a ratchet lever to be worked by hand. This enables the thickness of the flanges to be adjusted with precision. With this mill Messrs. Petin, Gaudet & Co. have rolled girders of 40 inch high, 33 feet long, and feel confident they could make them 90 feet in length." We have said that the essential features of this mill were applied in the United States, more than fifteen years ago, but in the mill at Trenton the axes of the driver rolls and of the friction rolls were at right angles to the mill of Petin, Gaudet & Co. That the latter is a better working arrangement than the former there can scarcely be any doubt.

It is no argument against the universal mill that the immense products exhibited in Paris as resulting from its operation are mere *tours de force*. No doubt a careful observation of the various structures in process of erection on the continent would fail show that these remarkable specimens of rolling have yet been brought within such limits of cost as to admit of their use in building. We know that in the Exposition building itself, no rolled beams were to be found of a greater depth than nine inches; and it is a fact that in the very many structures which are now being put up in the capital of France in which iron beams are invariably employed to the exclusion of wood, four-inch, six-inch and seven-inch are the dimensions most generally employed. But now that it has been found possible to produce beams of such large dimensions by the simple process of rolling, Mr. Hewett himself observes, "it is but reasonable to expect that the cost will be reduced as experience is gained, and that the large single girders will gradually replace the riveted girders, which even in the palace of the Louvre are invariably employed for spans of any considerable extent."

The universal mill had its origin in this country, but it came out at a time when its importance was not correctly estimated here; nor, so far as it relates to beams of the class we have been writing about, would its application have been of much value in England at this time. Now the mill is getting into use. The most recent train of this kind is intended for rolling long narrow plates without the necessity of their being afterwards sheared.

STRESS DIAGRAMS FOR STRAIGHT RAFTER ROOFS.

In a former article* we explained how the stresses in a Warren girder can be determined by means of a simple and easily constructed diagram. We will now proceed to determine the stresses in some of the commoner kinds of iron roofs—such as are indicated in figs. 1 and 3. In the form most commonly used in England, fig. 1 represents a roof with four bays to each half. The first step is to determine the load which produces the most unfavorable stresses in the different bars. In general, this load is not the same for all the bars; but in the present case, in which the top and bottom beams A C and A J are straight and meet at the end points A and B, the greatest load possible uniformly distributed over the whole rafter gives the greatest stresses in all the bars. We have, therefore, to consider this load only. It consists, first, in the dead weight of the girder; second, the weight of the covering; third, in the greatest possible load of snow which may fall on the roof; fourth, the maximum pressure of the wind. The girder ought to be loaded at the connecting points only—that is to say, at the points A D E F C, &c., for otherwise the bars of the top beam would have to sustain bending forces requiring more material than for mere tension or compression. We, therefore, suppose that the covering rests on the girder only at these points. When one of these points, E, for instance, is loaded with the weight upon half the bay D E and upon half the bay E F, or when the top beam is divided into equal portions, the load upon one connecting point is equal to the load upon a rectangular superficies extending in length from one rafter to another, and extending in breadth from one connecting point of this rafter to the next. The weight resting upon the points A and B does not affect the construction, as these are directly taken up by the support. Let us now suppose the weight on each connecting point to be two tons. Then the whole load on the girder is 7 by 2, or 14 tons. As this is symmetrically distributed with regard to the two supports A and B, each of these has to take 7 tons. These data are sufficient to determine the stresses, and we will begin to construct the diagram of forces.

We employ in this instance a mode of denoting the bars and forces which is much more convenient than that used in the former article. Structures to which the graphical method is applicable consist of bars forming a number of triangles, and we accordingly write in each of these triangles a figure, successively numbering these triangles in their natural order. In figs. 1 and 3, this is done by the numerals 5, 6, 7, 8, 9, 10 and 11. Opposite each top and bottom bar other figures are placed, and it will be observed that for all the bottom bars the figure 0 is used, whilst the bars in the top plane have different numerals, 1 2 3 4. This difference is due to the fact that the bottom is not loaded. If one of the connecting points at the bottom—for instance the point C in fig. 1—were loaded, we should be obliged to use, to the right and left of the load at C, different numerals. In this way each bar has at each of its sides a figure by which it is clearly indicated. The top bar, E F in fig. 1, is thus denoted by 2 8, whilst 6 7 denotes the bar E G. Similarly the load at point E may be denoted by 2 3. This mode of marking the bars will, perhaps, appear at first rather strange and arbitrary; but we shall see further on that it greatly simplifies the indication of the forces in the diagram of stresses and the correspondence between the two figures.

The process of constructing the diagram of forces for this roof is exactly the same as in the former case of a Warren girder. We begin at the point A, where the known resistance of the support acts with a force of 7 tons. This we have to decompose into two components with the directions of the bars 4 5 and 5 0. Draw a line 0 4 (in fig. 2) parallel to the force A in fig. 1, and therefore vertical, make its length to any scale, equal to A, or, in our case, equal to 7 tons. Through the two end points 0 and 4 draw lines parallel to the directions of the bars 0 5 4 5, and let these lines meet at the point 5. Then 0 5 and 4 5 in fig. 2, determine the forces respectively acting in these bars. To ascertain if these forces produce tension or compression we follow round the triangle 0 4 5 in the direction which is prescribed by the direction of the known force 0 4. We find that the force 4 5 acts from 5 to 4 and 0 5 from 0 to 5. In the girder, fig. 1, these forces act parallel; the force in 4 5 acts parallel to the direction from 5 to 4; or from D towards A in fig. 1. It, therefore, produces compression; similarly, the force in 0 5 acts in the direction from 0 to 5 in fig. 2; that is, from A to C in fig. 1, pro-

*See Van Nostrand's Magazine, Vol. I, No. 1, p. 13.

FIG. 1.

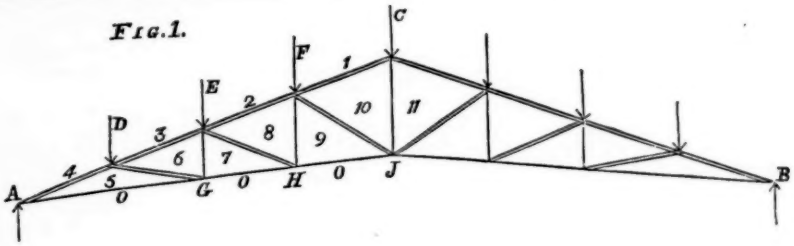


FIG. 2.

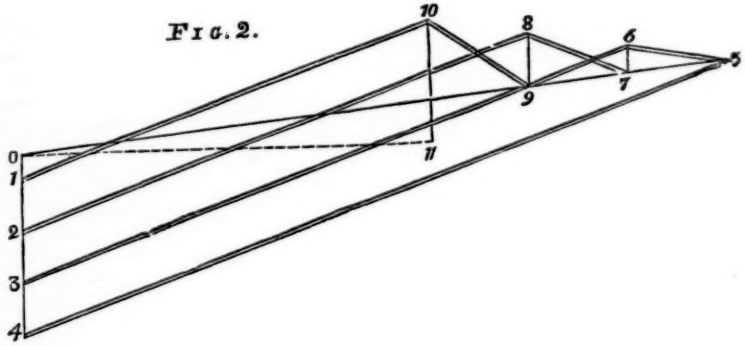


FIG. 3.

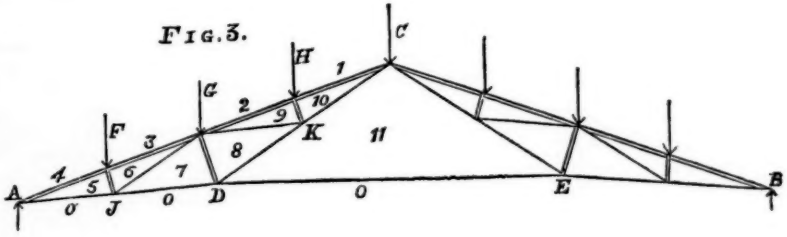
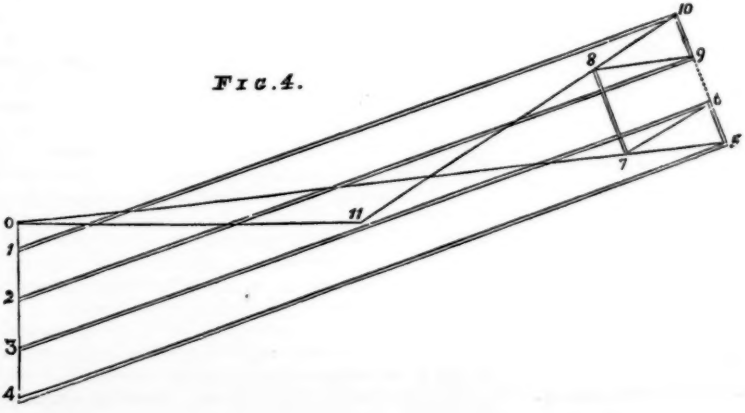


FIG. 4.



ducing tension. Compression is again denoted by a double line in both figures. We now go to the point D, where we have to combine 4 5 with the load 3 4 of two tons; and to decompose the resultant into the directions of 5 6 and 3 6. We remember that the compressed bar 4 5 presses at the point D in the direction from A to D; or, in this diagram of stresses, in the direction from 4 to 5. To this force 4 5 we add the load 3 4. The line adjoining 3 5 would give the resultant of the two known forces acting upon the point D. It is unnecessary to draw this line. We decompose this force with the given directions by drawing through the end and points 3 and 5 two lines parallel to our two bars 5 6 and 6 3 in fig. 1. Let 3 6 and 5 6 be these lines, which intersect at 6. Then 3 6 in fig. 2 is the stress acting on the bar 3 6 in fig. 1; and 5 6 that acting upon the bars 5 6. To find the direction of these forces we follow round the polygon 3 4 5 6 in the direction determined by the known forces 3 4 and 4 and 5, which are, as required, placed together in such wise that they travel the same direction by passing along these lines from 3 over 4 to 5. Proceeding, we pass from 5 to 6, and from 6 to 3. Hence the force 5 6 has in fig. 1 the direction G to D. It presses against the point D, and has, therefore, to sustain compression; and 3 6 has likewise compression. We next come to the point G, where 5 0 and 5 6 act as known stresses. They are represented in the diagram of stresses by the lines having the same figures and placed in the same way as they point in the direction 0 5 6. Drawing through the end points 6 and 0 lines parallel to the bars 6 7 and 7 0, we get the lines 6 7 and 7 0 as stresses in these two bars. They act in the direction from 7 to 6 and from 0 to 7; or in fig. 1 in the direction from G to E and from G to H, as we follow round the lines in the direction 6 5 0 7 6 0. Hence both bars are undergoing tension. In this case, the line 0 7 coincides in direction with 0 5, but by our present mode of notation an ambiguity is impossible. We thus continue, necessarily taking the points E H F J. Drawing from each point the corresponding lines in the diagram of stresses we obtain fig. 2.

This diagram determines all the stresses. Measuring all the lines with the same scale by which the first line 0 4 is made equal to 7 tons, we obtain the stresses directly. Only the stress 10 11 in the center tie-rod is not given at its proper amount. The line given in the diagram represents the tension down to only one-half of the rafter; but as this bar belongs equally to the second half, the stress, as taken from the diagram, is to be doubled.

Here, as in the case of a Warren girder, we have determined all stresses by expressing for each connecting point that the forces acting upon that point are in equilibrium. We began at one of the supports and proceeded by taking the other connecting points in their natural order till all the stresses were found. This process is always possible, unless it should happen that these forces are unknown at one point. This is not the case with the rafter, fig. 3, which illustrates a form of roofing much used in France and Belgium, and known in England under the name of the French roof. A diagram as simple as that in the former case enables one to determine all the stresses.

We again suppose the rafter, fig. 3, to be loaded at the connecting points F G H C, and so on for the other half, and with equal weights—say 2 tons at each point. The whole load will be 14 tons, half of which comes upon each support. This load of 7 tons we represent by the vertical line 0 4 in fig. 4, and divide it at the points 1 2 3 in such wise that 4 3, 3 2, 2 1, each represent 2 tons, corresponding to the loads at the points F G H. The remaining part 1 0 is then equal to half the load at C. Through the points 4 3 2 1 draw lines parallel to the top beam A C, and through 0 draw a line 0 5 parallel to the bottom beam A D, which cuts the lowest of the former lines at 5. Through this point 5 draw a line 5 10 parallel to the struts 5 6, 7 8, 9, 10, or at right angles to 4 5. This line determines the points 6 9 10, and the forces in the top beam by the lines 4 5, 3 6, 2 9 and 1 10. Lines drawn through 0 and 10 parallel to D E and D C meet at 11, and determine the stresses 0 11 in the great tie rod D E, and in the bar 10 11. To complete the diagram it only remains to draw 9 8 and 6 7 parallel to the corresponding bars in the elevation, fig. 3, and to join 7 8. Having done this, all stresses are determined, and the figures at once show which line in the diagram represents the stress in any bar in fig. 3. Double lines represent compression, and single lines tension.

The correctness of this diagram has now to be proved. Beginning, as before, at the support A we easily see that 4 5 and 0 5 are the two forces. Knowing these, we de-

termine the next ones, which meet at the points F and J. Here we stop; for if we proceed to the point G the *three* forces 7 8, 8 9 and 9 2, are unknown; and if we try to take the point D first, then again three forces have to be determined, namely, 7 8, 8 11 and 11 0. The diagram is, indeed, found by a somewhat differing method; but it being once given it is easy to be seen that it must be correct, for it gives stresses which are in equilibrium at each connecting point. The forces, for instance, acting upon the point G are given by the figures placed round G, namely, by 3 6 7 8 9 2 3. These figures, in fig. 4, are the angular points of a polygon of forces, and, as this is closed, we have equilibrium at G. Similarly for all other points. By following such a polygon round in the direction determined by any of its forces, we further ascertain which bars undergo compression and which have tension. In the polygon for the point G, for instance, the load G or 2 3 acts in fig. 4 in the known direction from 2 to 3. Hence, following round in the direction 2 3 6 7, &c., we see 3 6 acts from 3 to 6, and parallel in the elevation, or towards the point G. Thus 3 6 undergoes compression, and so on for the others.

These diagrams show very strikingly how the stresses alter with the inclinations of the top and bottom beams. Suppose, for instance, we make the top beam in fig. 1 more inclined, then the line 4 5 in the diagram of forces will turn round the point towards the line 4 0. The point 5 then moves towards 0 in 0 5, whereby the lines 4 5 and 5 0 are rapidly shortened; and similarly with all the other lines in the diagram. Hence all the forces decrease by giving the top beam a greater incline, or by increasing the depths of the rafter.

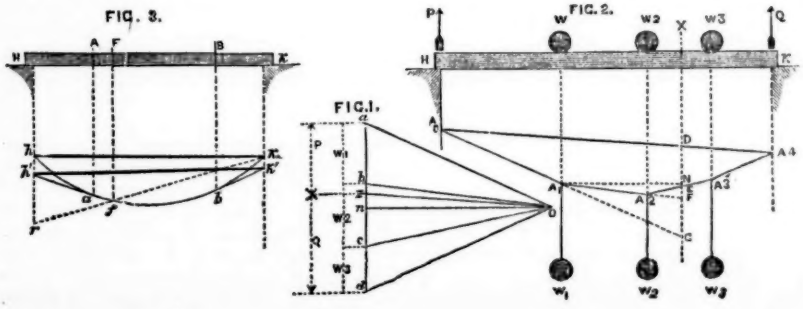
The above is from the "Building News."

The same subject is treated by James H. Cotterill, M. A., in "Engineering," under the following title:

ON THE GRAPHIC CONSTRUCTION OF BENDING MOMENTS.—It has long been known that the ordinates of a funicular polygon, corresponding to a system of parallel forces in one plane, represent the bending moments produced on a beam by the action of those forces; at least, such a principle has been employed in special problems, though, perhaps, never distinctly laid down as a general property of the funicular polygon. For instance, it must have struck every one who has considered this subject that the curve representing the bending moment at any point of an uniformly loaded beam is identical with the curve in which a chain hangs under a load, which, like that of a suspension bridge platform, is uniformly distributed horizontally. Also, it is not difficult to perceive that the multiplier by which the numerical value of the bending moment is obtained is the horizontal tension of the supposed suspension chain.

The remarkable construction now to be explained is founded on this property of the funicular polygon, and, as it appears to be very little known, I have thought that a short notice might interest the readers of this journal. It is, so far as I know, due to Prof. Culman, of Zurich; and I am acquainted with but one other writer who uses it, namely, Prof. Reuleaux, in his valuable work "Der Constructeur" (Note 1).

In Culman's work (Note 2) the properties of the funicular polygon are very thoroughly investigated, and a whole system of applied mechanics founded thereon; but the construction for bending moments, which appear to me to be of considerable value, may shortly be demonstrated thus: "Take, for



example, a beam, H K, supported at H K, and loaded with weights, W_1, W_2, W_3; it is required to find the supporting forces, P Q, and the bending moment at any section, X (Fig. 2).

Set off on a vertical line, ab, bc, cd, to represent the weights, W_1 W_2 W_3, respectively on any convenient scale (henceforward called the scale of tons.) (Fig. 1.)

Join a, b, c, d, to any convenient pole, O, thus forming a figure which may be called the diagram of forces, and draw the polygon, $A_0 A_1 A_2 A_3 A_4$, with sides parallel to Oa Ob Oc Od, and corners vertically below the supporting forces, P Q, and the load, W_1 W_2 W_3; then $A_0 A_1 A_2 A_3 A_4$ is the form in which a rope would hang if fixed at A_0 A_4, and loaded with W_1 W_2 W_3, for the sides of the triangles, Oab Obc Ocd, are parallel to the forces which act at the points A_1 A_2 A_3, respectively. Suppose now $A_0 A_4$ to be joined, and instead of $A_0 A_4$ being fixed points, let the side, $A_0 A_4$, be a solid bar, and the closed funicular polygon thus formed be suspended by strings from the points of support of the beam. Then evidently the tensions of these strings are P Q; thus P Q are immediately got by drawing Oz parallel to the closing side, $A_0 A_4$, in the diagram of forces; for, from the equilibrium of the points, A_0 A_4, represented by the triangles, Oaz Odz; za represents P, and zd represents Q.

Again, to find the bending moment at any section, X, of the beam, drawing the vertical through X, cutting the sides of the polygon on the sides produced, in D E F G; also draw A_1 N horizontal to meet this vertical in N, and in the diagram of forces, O n, perpendicular to a b c d.

Then by similar triangles

$$\frac{F\,G}{A_1\,F} = \frac{a\,b}{O\,b} \text{ and } \frac{A_1\,F}{A_1\,N} = \frac{O\,b}{O\,n}$$

$$\therefore \frac{F\,G}{A_1\,N} = \frac{a\,b}{O\,n} = \frac{W_1}{H}.$$

Where H is the horizontal tension in the funicular polygon represented in the diagram of forces by the polar distance, O n.

$\therefore$ H. F G = W_1 . A_1 N = moment of W_1 about X.

So in like manner

H. F E = moment of W_2 about X,
and H. G D = " P " "
therefore H. D E = bending moment at X.

Thus the bending moment at any point, X, of the beam is the force represented by the polar distance O n, in the diagram of forces acting at an arm equal to the length of the intercept, D E, between two sides of the polygon. The rule, therefore, is, measure the polar distance on the scale of tens, and the intercept on the scale of feet; then the product is the bending moment in foot tons.

This result may also be obtained by considering A_0 A_1 A_2 A_3 A_4 as a girder, and applying the method of sections.

The construction here proved for three weights can evidently be extended to any number; its advantage consists mainly in the fact that the position of the pole, O, in the diagram of forces is entirely arbitrary, and can, therefore, be assumed so as to satisfy any convenient conditions. Suppose we require the stress on each bar of a half lattice girder loaded in any way, it will be convenient to choose a polar distance numerically equal to the depth of the girder, for then the intercepts corresponding to any point read off on the scale of feet will be the stress on the opposite bars in tons.

Or again we make the polar distance 10, then the intercept corresponding to any point read off on a decimal scale, with the decimal point moved one place to the right, is the numerical value of the bending moment. Thus a series of bending moments are obtained much more quickly than by any calculation method.

The construction will also be found of considerable value in estimating the effect of a partial load on a girder; an example will show what is meant. Let the beam H K be uniformly loaded between A and B; then to find the bending moment at any point we have only to draw the parabola h a b k, which would represent it if the beam were completely loaded, and at points in the parabola corresponding to a b, draw tangents cutting the verticals through H K in h' k'; then h' k', b a is the polygon for the partial load, the multiplier being the same as for the complete load. (Fig 3.)

The form which the construction assumes, when one or more of the weights is outside the points of support, is interesting. In this case the closing side of the polygon usually intersects two or more of the remaining sides; the corresponding points in the beam are points of contrary flexure, and converse f, if their position is known the polygon of moments is at once determined. For example, let H K be fixed at H, supported at K, and uniformly loaded; assuming the point of contrary flexure, F, we find

the corresponding point, *f*, in the parabola, then *k f r* is the closing line, and *h f b k f r* is the polygon of moments.

It may be added in conclusion that the shearing force at any point of a beam is known at once from the diagram of forces, thus in the case of the beam first considered, the shearing force is *z a* between P and W_1, *z b* between W_1 and W_2, *z c* between W_2 and W_3, *z d* between W_3 and Q; this enables the stress on the diagonals of a half lattice girder to be obtained from the diagram of forces by drawing parallels to meet a horizontal through *z*.

Royal School of Naval Architecture, December, 1868.

NOTES.—1. *Der Constructeur.* Van F. Reuleaux, Braunschweig, 1865. 2. Die graphische Statik, Leipzig, 1864.

RAILWAY STATION ARCHITECTURE.

THE LONDON STATIONS—REQUIREMENTS—THE ST. PANCRAS STATION.

The requirements of station architecture are discussed at length by the "Building News," from which we compile the following facts and conclusions. The light and elegant Moorish style is considered peculiarly adapted to iron construction, and hence to station architecture. The classical orders are exclusively for stone. Even the slender Corinthian or Ionic shaft, in iron, is manifestly a sham, and our common sense rebels against it. How, then, is it with the stout Doric column with its massive capital?

The Great Western station at Paddington is cited as at once elegant and suitable. It is in three spans, crossed by two transepts, an arrangement which gives it intricacy and picturesqueness, and conveys an idea of something approaching to comfort, if such a thing can possibly exist in connection with a railway terminus. The girders are pierced in the web with various devices; the columns are light and of Moorish character, and the whole is airy and elegant. The supports to the roof are in the way of nobody, the ventilation is perfect, and the roof is so low that it does not obtrude itself upon the neighborhood; if it did it would not be an offensive object. While Paddington terminus exists let no one say that any other must be either huge or hideous.

The Charing Cross (single span) is one of the monstrosities which it seems to be nobody's business to interfere with while in progress, and everybody's duty to condemn when completed. It is very long, very wide, very high, and very hideous. The walls afford capital accommodation for advertising boards, and this is the utmost that can be said in its praise. Were the walls lower and the roof a complete semicircle it would have been less offensive. It is, indeed, rivalled by the Cannon Street station, and it is difficult to award the palm of supreme ugliness to either without doing wrong to both. The large span is not justified by the plea of freedom from obstruction as to columns for support of two or more smaller spans, inasmuch as the platforms are both here and at Cannon street encumbered with lampposts, which are to all intents and purposes as much in the way as a column to support a girder. Neither is it justified on the score of superior ventilation.

The Southwestern station is in three spans similar to those at Paddington, and the lamps are suspended, not set upon standards. There is no pretension to elegance or ornament, but it accommodates its traffic, is well ventilated, and does not offend the eye.

Other stations in London are mentioned, and the cheapness and suitableness of several low spans, rather than one immense span is advocated. Columns are not objected to. They separate people into two lines and prevent jostling; they form spots where people can harbor and exchange a few words without being elbowed, and where a bag or parcel can be temporarily deposited with less risk than on the open platform.

The King's Cross station exhibits the failure of a too readily adopted constructive principle. For a long time the circular ribs, built up in the laminated method, and consisting of five two-inch planks bolted together, have been losing their shape; they have sunk at the crown of the arch, and are undergoing repairs. It is probable that they will have to be replaced with iron.

THE ST. PANCRAS STATION.—The construction of the new station of the Midland Railway is pronounced excellent. This immense work, recently completed, has been the subject of various essays and illustrations in the London press during the past year. The following graphic description is from the "Railway News." This building has the largest continuous roof of any building in the world. It is 690 feet long, and 240 feet wide. Bare figures, however, fail to

convey such an idea of the structure as may be afforded by comparison with others familiar to our readers. The Central Transept of the Crystal Palace is 120 feet wide, or exactly half the width, and 384 feet long, or rather more than half the length of the Midland station. The dome of St. Paul's is 100 feet in diameter; two and a half of these domes might be brought into the station if it were 250 instead of 240 feet wide. Charing Cross station is 168 feet, Cannon street 188 feet wide; the Midland is 240 feet in width, or nearly half as wide again as the roof of Charing Cross.

There is, too, this great feature in the Midland that distinguishes it from all other stations and buildings of its class. There is no network of girders nor of rods intersecting each other at every angle, creating a maze of intricate iron-work, and detracting from the general effect of the bold outline which would otherwise be presented. Enormous iron ribs, in shape something like the monster jaw-bones of whales, and 25 in number, start from the ground on each side, and meet in the centre at an elevation of more than 100 feet above the floor of the station. Iron plates, secured by millions of rivets, build up these ribs, until each of them weighs something like 50 tons, and if bent straight would be 400 feet in length, or nearly the height of St. Paul's Cross from the ground! To prevent the feet of these ribs from starting outward there are fifty huge girders resting upon 1,100 iron columns, more than a foot in diameter, and which, like the string of the bow, keep the frame-work rigid and immovable. To make these binders still more secure, there are 2,000 other iron girders, which cross and recross, and form a network of iron bracing. All this is below the floor of the station, and it supports the roof of four and a half acres of cellars underneath the station.

This large area under the station is to be used for the storage of beer and merchandise, and contains fifteen ranges of cast-iron columns. There are forty-six columns in each range, or six hundred and ninety in all. They stand at about fourteen feet six inches apart. These columns, and the piers upon which the principals rest, have all their foundations upon the London clay. Over the clay is spread a floor of concrete seven feet thick, and upon that a broad sill-plate, upon which the columns are set. The spaces between the intersections of the girders are covered with Mallet's buckle-plates, and a surface is thus provided strong enough to bear, without deflection or rupture, any weight that may be brought upon it. In addition to the binding by the girders, the feet of the principals are further secured by a pair of bolts 24 feet long and four inches in diameter, which pass down through the piers, and are fastened to the anchor-plate below by nuts six inches deep. These invisible bindings of enormous strength, are important contributories to the lightness and elegance of the great arch. Along the sides of the station, and outwards to the streets, ranges of arched spaces are built, to be let as shops and places of business. Their fronts, in the Gothic order, and which reach to about the height of the station platform, add greatly to the effectiveness of the immense structure by their quiet enrichments, and by dividing the vast surface of dead wall that would otherwise have been presented.

The walls of the station, unlike those of Charing Cross and Cannon street stations, perform no part in sustaining the roof of the building; this work being thrown, as we have explained, entirely upon the iron ribs which spring from the ground floor. The walls are picked out with white stone; a tesselated frieze of handsome design, inlaid with colored tiles, forms an agreeable ornament, the moulding above which is surmounted by an iron cresting of floral design, the leaves curling inwards from the cornice. Recessed pointed arches and small quatrefoil windows at intervals in the side walls complete the architectural effect as viewed from the interior, which presents a light and agreeable appearance.

The construction of this gigantic roof necessarily involved great difficulties. An enormous traveling stage; similar to that used for the domes of the Exhibition building of 1862, was built up. This stage is 100 feet in length, width 240 feet, depth 90 feet; it contains more than eight miles in length of solid timber, and weighs over 1,300 tons. The huge mass rests upon small wheels, and may be moved about on its tramway as desired, by levers. Such is the extent of the work that there were employed upon the station for the greater part of the time 6,000 men, 1,000 horses, and 100 steam lifts of various kinds.

In the designing, as in the carrying out of this noble station and approaches, Mr. W. H. Barlow has completed a work which will deservedly place his name among those of the most eminent of his profession. The

external architecture is the design of Mr. Gilbert Scott. The detail drawings of the iron work were furnished by Mr. Ordish, and the work was supplied by the Butterly Iron Company.

GIGANTIC WATER WORKS.—A manufacturer of Lyons proposes to supply that town with an amount of water which no city in the world possesses. His plan is to draw from the Lake of Geneva ten tons of water per second, or 864,000 tons in twenty-four hours. The population of Lyons being 330,000 souls, this would give each 2,618 litres of water per diem. Rome, the best supplied city in the world, has 1,500 litres per head per diem, New York 568, Marseilles 470, Bordeaux and Paris each 170, London 110, Brussels 80, Geneva 74, and Lyons, at present, only 60 litres. The proposed canal or conduit would be divided into three sections: (1) An open canal 55 miles long, having a water section 21ft. .wide, and about four ft. deep; (2) a covered conduit in masonry, 31 miles long; and (3) nearly eight miles of syphons for the crossings of the valleys.—*The Engineer.*

GOOD MARINE ENGINEERING.—The British iron-clad Hercules, 325 feet long, 59 feet wide, and of 8,600 tons displacement, recently steamed 14.7 knots, or over 17 miles per hour, while drawing 23 feet forward and 26½ feet aft, and developing 8,528 horse power. The remarkable feature is that the engines complete and boilers with water weigh but 1,095 tons, or 2½ hundred weight, per horse power.

MORTON'S EJECTOR-CONDENSER.

Compiled from Prof. Rankine's paper before the Institution of Engineers in Scotland, and the subsequent discussion, and from articles in "Engineering."

One of the most remarkable devices connected with the steam engine, that has appeared since the Giffard injector, is the condensing apparatus described in this article. Indeed, Professor Rankine pronounces it the most important improvement made in the steam engine, since the days of Watt. Its action is briefly this: While in the ordinary condenser, the force of the steam and water rushing in are entirely wasted, and require a pressure of 0.6 lb. per square inch on the steam piston to pump them out and maintain a vacuum, the Morton condenser utilizes the force of the steam and water entering it, and dispenses with the air pump. The exhaust steam and the condensing water simply rush into a sort of Giffard injector, and instantly come out of it in the form of hot water (and the contained air) without other assistance.

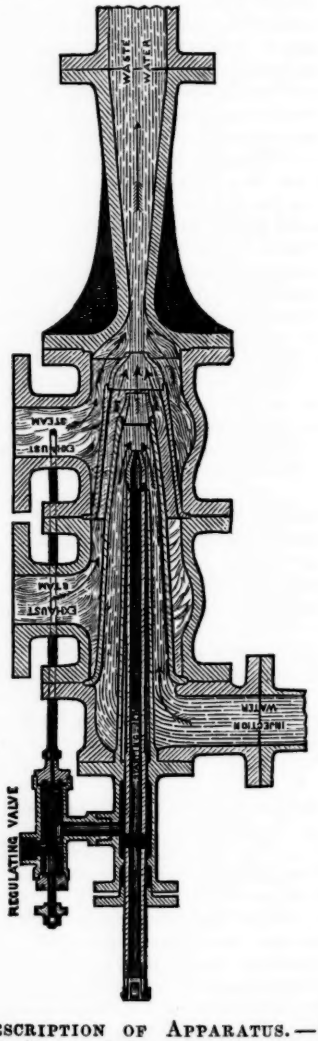
The experiments described were made at the request of Messrs. Neilson Brothers. The ejector-condenser, invented by Mr. Alexander Morton, was applied to a pair of vertical inverted direct-acting steam engines, which exerted collectively a power averaging about 24 indicated horse power. The nominal power of these engines is collectively seven horse power, if we apply the ordinary rule for low pressure engines, or fifteen horse power if we apply the ordinary rule for high pressure engines. The dimensions of the engines and of the condensing apparatus, and the results of the experiments, are given in detail in the annexed table; but as regards the engines it may be convenient to state here that their two cylinders were of eighteen-inch stroke, and about ten and a quarter inch diameter, that they ran at from 93 to 140 revolutions per minute, and that the steam pressure gauge indicated from 30 pounds to 40 pounds on the square inch above the atmospheric pressure, which at the time was 14.75 pounds on the square inch. It may be remarked that the experiments throw light on other questions besides the efficiency of the new condenser; and in particular, that the accurate measurement of of the quantity of condensation water, and of its change of temperature, affords the means of calculating the total expenditure of steam, and comparing it with the quantity of steam effectively used in doing work, as indicated by the diagrams. The circumstances under which the experiments were made were, to a certain extent unfavorable to the apparatus, for the pipe which supplied the tank from which the cold water was drawn for condensing the steam was of too small diameter, and the engines had from time to time to be stopped in order that the tank might be refilled.

PRINCIPLE OF ACTION.—The principle of the invention may be described as follows: In every injection condenser the cold water rushes into the vacuum with a velocity of 43 feet or 44 feet per second or thereabouts. The exhaust steam rushes from the cylinders into the condenser with a velocity which is

many times greater than that of the water. In the common condenser these rapid motions of the water and of the steam are completely checked, and their energy is wasted in agitating the fluids in the condenser, and ultimately in producing heat, and hence it becomes necessary to use an air pump in order to extract the water, air and uncondensed steam from the condenser. The power expended in working a well-proportioned and well-constructed air pump is known by experiment to be equivalent to that which would overcome a back pressure on the steam piston of from half a pound to three-quarters of a pound on each square inch of its area, or, on an average, about 0.6 of a pound on the square inch, and that amount of power is lost through the wasting of the energy with which the jets of water and steam rush into the condenser. In the ejector-condenser the motion of those jets meets with no interruption, and its energy is found to be sufficient, without any assistance from pumps, to carry all the water, air, and uncondensed steam (if any) completely out of the condenser and into the hot well, and thus to save the power which would be required to drive an air pump.

Paradoxical as Giffard's injector appeared, at first sight, its action admitted of perfectly clear explanation. In a boiler under pressure of 100 pounds per square inch, equal to a head of water of 230 feet, the water would rush out of any opening with a velocity (were there no friction, atmospheric resistance, or loss of head) of about 121 feet per second. But were an opposing jet to move with agreater velocity, it would drive back the escaping steam and force its own way into the boiler. This is what happens in the injector, and for a simple reason. A jet of steam moving with a velocity of perhaps 1700 feet per second is instantly condensed in perhaps twelve times its own weight of water. The combined jet will then move with one-thirteenth its former velocity, or about 131 feet per second, the motion of the steam being wholly imparted to the water. Thus the jet, properly directed, enters the boiler. In Morton's condenser, the escaping exhaust steam, properly directed, is condensed in, and its own motion imparted to, a jet of water previously set in motion by a small steam jet, and the experiments appear to show conclusively that the lateral action of the jet is sufficient to draw with it all the air that collects down to a vacuum of twelve pounds or thirteen pounds.

Mr. Morton's explanation of the action is that a jet of water in rushing into the vacuum has nearly sufficient power to take itself out, and the impulse of the exhaust steam from the cylinders makes up the energy that the jet looses in friction.



DESCRIPTION OF APPARATUS. — The principal parts of the condensing apparatus on which the experiments were made may be summarily described as follows: The cold water passes from the tank to a conoidal nozzle; the area of the orifice of that nozzle

is about equal to that of the injection sluice of a common condenser suited for the same engine; that is to say, about $\frac{1}{250}$ part of the collective area of pistons. Enveloping the cold water nozzles are a second and a third nozzle of nearly similar figure; these bring the exhaust steam from the two cylinders respectively. The middle nozzle has an orifice a little larger than that of the innermost, or cold water nozzle; the outermost nozzle ends in a throat or contracted vein, a little larger still, beyond which is a gradually widening trumpet-shaped mouthpiece, leading to a pipe which ends at the hot well. The condensation of the steam takes place in the interval between the orifice of the cold water nozzle and the throat of the outermost nozzle.

When this condenser was first constructed there was no stop-cock for shutting off the injection water, and in starting the condenser it sometimes happened that the attendant would shut off the main steam valve while there was a vacuum in the cylinders, and thus the water was liable to get into them. The inventor has now—that is since Professor Rankine's experiments were made upon the condenser—added a regulating spindle and cylinder, which cylinder contains a piston valve that opens with a spring immediately that the perfection of the vacuum in the condenser is interfered with. By means of this central regulating spindle the injection water current may be most nicely adjusted, or it may even be cut off instantaneously, and the engines can thus be made to work as high pressure engines at pleasure; indeed, its action is so certain and instantaneous that a cylinder full of air may be completely expelled during one revolution of the engine. When the engines are at work, and the regulating valve in action, the latter shuts off the central steam jet; and should any person open a grease cock, or otherwise admit air into either of the cylinders or the condenser, the loss in vacuum is instantly communicated to the regulating valve by the pipe. The action allows the valve to open the steam jet, and thus to displace the air.

While engaged in perfecting this new invention, Mr. Morton experienced the greatest amount of difficulty in connection with the exact parabolic shape which the discharge pipe should assume. This appendage may be regarded as the most important part of the apparatus, for without it the action of the apparatus would be practically useless for a condensing engine, as the steam on leaving the cylinders would require to be much above atmospheric pressure before any water could possibly be discharged. By gradually imparting to the discharge pipe the trumpet-mouth form, shown in the engraving, it was found possible to produce a vacuum of 13 lb. per square inch, with a water pressure on the entering side of the condenser of only two lb.; while to produce a similar vacuum required a water pressure of 50 lb. per square inch if a *vena contracta* nozzle were substituted for the trumpet-mouth of the discharge pipe; or, in other words, a water pressure of 50 lb. could be reduced to two lb. by gradually widening the mouthpiece to its present form, while the vacuum remained the same, and this without the use of any steam in the experiments. Prof. Rankine regards Mr. Morton's application of the trumpet-shaped mouthpiece to the steam engine as being quite a new and original invention, and indeed, as probably the most important improvement in the steam engine since the time of James Watt; and Sir Wm. Thomson considers the production of a vacuum of 13 lb. by the use of this appliance as a most wonderful result in a dynamical point of view.

THE EXPERIMENTS.—Table of experiments made on the 27th October, 1868, on a pair of engines at the works of Messrs. Neilson Brothers:

Cylinders:	
Area of each, allowing for piston rods, about	80 square feet.
Stroke	1.5 foot.
Cold Water Nozzle:	
Diameter 13-16	=0.8125 in.
Area	0.638 sq. in. =0.00443 sq. ft.
Water Tank:	
Area 8 ft. × 3½ ft.	=28 square feet.
Mean depth of surface below level of nozzle	5.25 feet.
Waste Water Nozzle:	
Diameter of throat 15-16 in.	=0.9375 in.
Area of throat	0.690 sq. in. =0.00479 sq. ft.
Diameter of mouth-piece	3.0 in.
Area of mouth-piece	7·07 sq. in. =0.0491 sq. ft.
Cold Water Supply:	
Mean rate of flow in cubic ft. per min., 28 ft. × 0.41 = 11.48	=716.4 lb.
Do. per second, 0.1913	= 11.94 lb.
Velocity of cold water through nozzle, ft. per second, $\frac{0.1913}{0.00443}$	= 43.2 lb. per sq. in.

Head due to that velocity.....	29 ft.	= 12.57	
Add mean height to which water is lifted.....	5.25	= 2.275	
Total head	34.25	=14.845	

Temperature..... 47° Fahren.

Mean work per minute done in raising and propelling water jet, exclusive of friction, 716.4×34.25. ..... =24537 ft. lb. =0.744 I. H. P.

Barometer: 30.05 in. mercury=14.75 lb. on the square inch.

Sets of Experiments.	Right Hand Cylinder.		Left Hand Cylinder.		
	A.	B.	C.	D.	E.
Nos. of diagrams	1	2.3 4.5	6	7.8	9
Revolutions per minute	130	93	abt. 140	107	108
Steam gauge above atmosphere. Pounds on the square inch	34	from 32 to 38	.....	35	from 40 to 30
Do. do. absolute	48.75	from 46.75 to 52.75	.....	49.75	from 54.75 to 44.75
Vacuum gauges below atmosphere.* Pounds on the square inch	12.03 11.54	12.4 12.1	....	12.3 11.8	
Do. do. absolute.	2.72 3.21	2.35 2.65	....	2.45 2.95	
Mean back pressure	4.25	3.12	4.50	4.38	4.00
Absolute pressure of release	10.75	10.80	8.75	12.00	10.50
Initial absolute pressure	42.75	38.25	32.75	42.75	42.75
Mean effective pressure	15.25	14.83	9.85	16.78	15.90
Mean absolute pressure	19.50	17.95	14.35	21.16	19.90
Temperature of waste water, Fahrenheit	86.5°	80.5°	.....	88.0°	91.0°
Elevation of temperature above cold water....	39.5°	33.5°	.....	41.0°	44.0°
Heat carried off by water. British units per minute	28298	23999	.....	29372	31522
Velocity of pistons, feet per minute.....	390	279	420	321	324
Load of one piston, lbs	1220	1186.4	788	1342.4	1272
Indicated work, one cylinder, ft. lb. per minute,	475800	331006	330960	430910	412128
" " two "	951600	662012	661920	861820	824256
Indicated H. P.....	28	20	20	26	25
Indicated work per minute reduced to equivalent quantity of heat	1233	858	858	1116	1068
Total expenditure of heat, British units per minute	29531	24857	.....	30488	32590
Efficiency of engines	0.042	0.035	.....	0.037	0.033
Volume of steam exhausted, as shown by indicator, in cubic feet per minute.....	433	310	467	357	360
Volume of one pound in cubic feet.	35	35	43	32	36
Weight of steam shown by indicator in pounds per minute	12.4	8.9	10.9	11.2	10.0
Temperature of steam at end of stroke, Fahr..	197°	197°	187°	202°	196°
Total heat per pound of that steam from temperature of waste water.....	1087	1093	.....	1086	1082
Heat of condensation of steam indicated	13479	9728	.....	12163	10820
Heat carried off by waste water (as before)...	28298	23999	.....	29372	31522
Actual expenditure of steam in lbs. per minute, as calculated from heat of waste water.....	26.0	22.0	.....	27.0	29.1
Proportion in which steam actually condensed exceeds indicated steam.....	2.10	2.47	.....	2.41	2.91
Work in foot pounds per minute saved by dispensing with the air pump, estimated as equivalent to 0.6 lb. pressure per square inch of steam piston	37440	26784	40320	30816	31104
Do. indicated H. P	1.13	0.81	1.22	0.93	0.94

* First result is for left hand, and second result for right hand engine.

Abstract of Principal Mean Results.

Mean power saved by dispensing with air pump, indicated horse power	1.0
Mean indicated horse power of engines	23.8
Mean back pressure in cylinders, lb. on sq. in.	4.05
Mean vacuum in cylinders, lb. on the sq. in.	10.7
Mean vacuum shown by gauges, lb. on sq. in.	12.0
Mean vacuum shown by gauges in inches of mercury	24.5
About two-thirds of the indicated power were due to the vacuum in the cylinders.	deg. F.
Temperature of the cold water	47
Mean temperature of waste water	83¼
Mean increase of temperature	36¼

The completeness and efficiency of the condensation were tested by vacuum gauges, and by indicator diagrams. By both means of testing, the left-hand cylinder, which exhausted into the middle nozzle, showed a rather better vacuum than the right-hand cylinder, which exhausted into the outermost nozzle. The average results of the whole of the experiments were as follows:

Mean vacuum shown by gauges, in inches of mercury	24.5
Mean vacuum shown by gauges, in lb. on the square inch	12.0
Mean vacuum in cylinders, during return stroke, as shown by the indicator diagrams; lb. on the square inch.	10.7
Which, being subtracted from the atmospheric pressure at the time	13.75
Leaves, as the mean back-pressure in the cylinders during the return stroke, in lb. on the square inch	4.05

The back pressure in different experiments ranged between 3 lb. and 4½ lb. on the square inch. These results are at least as good as the average results as to vacuum and back pressure obtained by means of the common condenser; and they show the condensation of the steam and expulsion of the water, air and vapor, to be at least as complete and efficient.

It is estimated that the saving of power through the dispensing with an air pump is equivalent to the doing away with a resistance of 0.6 lb. per square inch area of steam pistons, and it is found to be, on an average of the several experiments, just one horse power, being about 4 per cent of the mean indicated power of the engines. The energy of the jet of cold water is about ¾ horse power. This forms the greater part of the energy which is wasted in the common condenser, rendering an air pump necessary.

The temperature of the cold water employed was 47° Fahr., and the temperature of the discharge water was 83½° In common condensing engines the temperature of the discharge water would generally be about 120° with a similar vacuum, a fact which indicates that the new condenser consumer a larger amount of water than is consumed by the ordinary condensing jet. This is admitted, but it must be remembered that the latter gives a much hotter discharge water than the former. There is this fact, also, that the vacuum has recently been improved 1 lb. per square inch by making comparatively trifling alterations in the apparatus. The condensing water has been experimentally reduced 2⅛ times since the experiment described, with a proportional increase in the temperature of the discharge water and a loss in vacuum of 1.5 lb. The quantity of water now used is stated to be the same as with the ordinary condenser.

As to the height to which the discharge water could be lifted, Mr. Morton states that if the steam leaves the cylinder at about the atmospheric pressure, the water could be forced about 15 ft. high; a pressure of 5 lb. would force it 20 ft. high.

The abstraction of the air is perhaps the only thing that is really puzzling in the matter, unless it be that the very rapidity with which the steam concentrates upon and within the passing jet of water carries the air wholly against or even into the jet also.

But there is one thing in the record of experiments which requires some explanation. The units of heat imparted to the injection water were from 2.1 to 2.9 times those contained in the heat of condensation of the steam shown by the indicator. Not only this, but the steam represented by the increase of temperature imparted to the injection water amounted to more than 60 lb. per indicated horse power per hour. The different indicated horse powers recorded, the pounds of steam condensed per minute, and the pounds of water consequently used, as steam, per horse power per hour, were as follows, the last column being calculated in "Engineering" from the two first:

I. H. P.	Steam used per Minute. lb.	Water per I. H. P. per Hour. lb.
28	26.0	55.7
20	22.0	66.0
26	27.0	62.3
25	26.1	09.8

The quantity of steam used, representing from 7 lb. to 8 lb. of coal per indicated horse power per hour, appears excessive when the good rate of expansion, good vacuum, and good rate of piston speed are

considered. It might be suspected that, notwithstanding the assertion that no steam was used direct from the boiler to keep the jet in motion, the little regulating valve shown in our illustration was open, and thus it might prove that as much live steam was used to work the condenser as to work the engines themselves. This, however, is not said as in any way conclusive, but as a matter requiring explanation.

COST, ECONOMY AND ADVANTAGES.—As to cost of construction, Mr. Morton stated that his condenser would not cost more than one-fourth as much as the ordinary condenser and air pump.

The conclusions from the experiments are: First, that the action of the ejector-condenser is at least as efficient as that of the common condenser, with its air pump; and, secondly, that by the use of the ejector-condenser the power required to drive the air pump is saved. The construction is very simple, it has no moving parts which can get out of gear. It can work at any speed of engine, while a high speed of air pump is attended with difficulty; and it overcomes the objection which often arises from placing the air pump horizontally. When the engines are stopped, the vacuum may be maintained for any period of time, by simply opening the central starting steam jet, so as to overcome the friction of the water through the nozzles. The advantage of having a continuous vacuum in maneuvering marine engines in port is of great importance to the marine engineer, especially so in war vessels. In order to maneuver them with facility, in action, this result has been sought in naval vessels by means of independent air pumps. Mr. Morton said that with a small head of water, steam could be wrought down to the finest pressures. H ehad had that engine working at 28in. or 29in. vacuum by adding a head of water of a few feet to that condenser.

Professor Rankine believes that when the apparatus gets fair play, it will give as good results as the surface condenser; at present the results are as good as those with the common injector condenser. While the ejector-condenser is applicable to all kinds of land engines, it seems to be even more especially valuable as an appliance on board river passenger steamers, in which reduction of weight to the lowest possible amount is of the very utmost importance. There is also this advantage in applying Morton's condenser to marine engines, that it may be placed at any height in the vessel, and not necessarily at the lowest level, as is the usual practice with the ordinary form of condenser. It has been suggested that the apparatus might be of still further service in steam vessels by ejecting the water in a direction opposite to that in which the vessel is sailing, and thus assist in its propulsion—acting as a sort of Ruthven's propeller.

The new condenser cannot, of course, give distilled water for the boilers, as is done by surface condensers. Mr. Morton has, it is true, proposed to cool his injection water, originally fresh, by circulating it through a refrigerator, but with water in the hot well, at a temperature of only 90°, or even 110°, or, still more, 120°, it would require a refrigerator many times larger and more costly than a surface condenser to cool it again, by means of sea water at from 50° to 70°, to say nothing of the pumps required for circulating the cooling water.*

That the ejector-condenser is really a very effectual condenser at a low first cost may be inferred from the fact that the Scotch engineers have, in numerous instances, shown an anxious desire, and even a determination to make practical use of the appliance. It has already for some time been in operation at the Lugar Ironworks, in connection with an engine that was made some twenty years ago. Messrs. Robert Napier and Sons, marine engineers and shipbuilders, Glasgow, have lately ordered a pair of engines, with Morton's condensers applied, to be erected at their works at Govan. We understand that Messrs. William Simons and Co., shipbuilders and engineers, Renfrew, are busily engaged in making a pair of twin screw engines on Morton's principle of condensation; and other marine engineering firms on the Clyde are framing their contracts in accordance with their intention to apply the ejector-condenser. Some experiments recently made by Mr. James R. Napier, F.R.S., with the injection water heated to a temperature of 80° Fahr., show that even in warm climates the new condenser will not vary much in vacuum, and that practically it will give a vacuum very nearly equal to that which is due to the temperature. The experiments referred to were so satisfactory that Mr. Napier has resolved, we understand, to apply the Morton condenser to the engines on the Godavery river steamers, built by Messrs. Randolph, Elder and Co., for the Indian Government.

* Lighthall's refrigerator requires no circulating pump.—*Ed. Van Nostrand's Magazine.*

EXAMINATION OF CIVIL ENGINEERS.

Compiled from the "Building News."

A resumé of the questions submitted to candidates for engineer appointments in India. cannot fail to be important to young engineers, and is of interest to general readers. The questions in the first division referred to cements, concrete, mortar, &c. The candidates were required to describe Portland cement, its characteristics, the raw materials from which it is made, and the proportions used. Also the methods of manufacture and the machine, and mode of testing adopted by the engineers of the Metropolitan Board of Works. The proportions of sand to use for mortar had to be stated, and the best qualities of sand for cement mortar named; dimensions and weight of the largest concrete blocks that have been used in harbor works, and a description of the means employed for placing them *in situ*, and where so employed.

The examiner strongly recommends a careful study of Mr. Henry Reid's book, lately published on this subject.* In his remarks on the writing of candidates he advises the cultivation by engineers of a clear, concise, and vigorous style of expression, and he directs their attention to the masterly reports and writings of Smeaton, now unfortunately out of print, but extracts from which, together with those of Watt, Telford, the elder Rennie, Stephenson, Brunel, Locke, and others, he hoped to see shortly published. Such a work, he thinks, would be to the engineer what the Despatches of Wellington are to the military man.

The questions of the second division relate to building materials—brick, stone, timber, &c. Statements were required of the candidates' opinions as to the selection of clay suitable for bricks, its preparation for the moulders, methods of moulding, and arrangements for burning, the latter to be accompanied by a free-hand sketch. Candidates were required to describe the different sizes and kinds of bricks, to illustrate the various bonds employed, and to explain how a bond is sometimes defective in a two-brick wall. A description had to be supplied of the various kinds of stone and timber, and the principal processes employed to preserve the latter from decay and iron from corrosion. The principles of the artesian well, Norton's tube pump, and Mather and Platt's apparatus for well-boring and coal sinking, were required, with particulars of existing wells sunk on the artesian principle. Concrete, now coming more largely into use for building operations, the importance of fuller acquaintance with that material and its capabilities, is insisted on.

The construction of bridges, especially suspension bridges, forms an important part of the examination. Candidates were to describe the difference between the ordinary suspension bridge and a bridge (of which illustrations were furnished) stiffened by suspension rods from the towers to various points in the floor. They had also to state approximately the area of iron required in one of the chains of a suspension bridge having two or more spans of ordinary construction, both at the points of support, viz.: top of tower and at the centre of span; the span being 500 feet, and the versed sine of the curve formed by the chains being 40 feet; the weight of one chain, together with its load, being half a ton per lineal foot, and the strain upon the iron not exceeding five tons per square inch of section. A description of the construction of the Menai, Lambeth, Clifton and Niagara Falls suspension bridges was required, and the spans of the largest bridges hitherto constructed, with the means adopted to obtain a rigid roadway. Free-hand sketches had to be made to accompany descriptions of Mitchell's screws for cast iron bearing piles for piers of bridges, foundation supports for lighthouses, jetties, &c.

The great importance of the study of architecture is strongly insisted upon. The drawing which accompanies the questions is an original design of a range of public offices with a large dome rising in the centre, and flanked by two smaller ones of similar external construction. Candidates were expected to furnish a description of the methods of its erection, to name the style, and to distinguish the different parts. Most of the questions on architecture are of a very elementary character.

The concluding list of questions bears on iron and its applications. The principal things required of the candidate were, statements of the limits in scantling embraced in the trade quotations for "bar iron"—say, in the cases of "flat," "round," and "square" iron; the difference in price of bar iron and angle iron; the limit in dimensions of angle iron comprehended in the said

* And largely compiled without credit from Gen. Gillmore's work on limes and cements.—*Ed. V. N.'s Magazine.*

difference in value, and the usual scale of additional charges for angle iron exceeding the limited dimensions; the price per ton of boiler iron, as exceeding that of bar iron, and the extra charges known in the trade as "best" and "best best;" also, the meanings of the terms "singles" and "doubles;" the comparative costs of steel and iron, with their respective advantages. The concluding question requires by way of answer a description of the process of manufacture of corrugated galvanized iron.

The list of books recommended by the examiner is as follows: "The Roorkee Treatise on Civil Engineering," edited by Major J. C. Medley, R. E.; "The Elements of Practical Hydraulics," by S. Downing, LL. D.; "Practical Treatise on the Manufacture of Portland Cement," by Henry Reid, C. E.; "Irrigation in Southern Europe," by Lieut. C. C. Scott Moncrieff, R. E.; "Italian Irrigation," by Colonel R. Baird Smith, R. E.; "On Public Works in India," by Sir Arthur Cotton, R. E.; "Account of the Ganges Canal," by Colonel Sir Proby Cautley, C. B.; "Ferguson's Works on Architecture."

GAS AS A CALORIFIC AGENT.

"Gas-Light Journal."

While the use of coal-gas for illuminating purposes has extended rapidly, in this country at least, its adoption as a calorific agent has been so slow as to disappoint the hopes of its early advocates. The advantages claimed for gas in this respect are cleanliness and freedom from trouble, it being unnecessary to carry coal or other fuel to feed the fire, or to remove ashes, etc. The rapidity with which heat may be generated and the ability to instantaneously extinguish the fire are great recommendations—particularly in summer when it is desirable to perform the duties of the *cuisine* with as little elevation of temperature as possible.

In England, and particularly in London, gas is largely used for cooking, and it is said to perform its office most acceptably. For families living in apartments, where the trouble and expense of carrying coal or other fuel would be great, gas has proved a great desideratum. By means of approved burners, and admixture with the proper portion of atmospheric air at the time of consumption, a large amount of heat is generated, and where sufficient ventilation may be had, the products of combustion are readily conveyed away, causing no inconvenience or injurious results. Possessing these advantages, it may appear strange that it is not more generally adopted; doubtless it would be, but for the high price of gas in this country; the ordinary methods for generating heat have the preference because of their economy. The probability is that if the price of gas were reduced, so as to make it practicable to employ it for heating, the demand for it would increase in a large ratio, and the concession might be more than atoned for in the enlarged sales which would undoubtedly follow.

That the calorific properties of gas are equal to other agents used for heating, is proved by the fact that in analytical chemical laboratories, charcoal and other fires have been, to a considerable extent, replaced by gas, and the operations of boiling, evaporation, fusion, ultimate organic analysis, and even cupellation, are now performed by easily regulated gas furnaces, their use conducing far more to the personal comfort of the operator, than the troublesome and cumbersome stoves formerly employed. The inventions of gas furnaces, such as are constructed by Griffin and others in England, and Krause and Haskins in this country, have displayed much ingenuity, and, by their use, the laboratory of the chemist presents a much cleaner appearance than formerly—no dangerous sparks or cinders being formed, nor ashes being blown about the room, to the detriment of other substances in the vicinity.

From the success attending the use of gas stoves in the laboratory, it is safe to assert that many of the operations of the household could be performed in the same manner.

The introduction of the improved process of manufacturing gas by the Gwynne-Harris plan of decomposing high steam to produce hydrogen as a heating agent, and for a motive power in lieu of steam power, is commencing a new epoch in the history of political and domestic economy. The same process applied to the ordinary coal gas manufacture lessens the first cost of production so greatly that it will soon be a matter of consideration with gas companies whether the selling price may not be lessened, with a view to its introduction into these new industries; thus opening a much more extensive demand, which, in the aggregate, will largely increase the dividends of gas companies, and add a new element to the progress of the age.

BRIDGE CONSTRUCTION.

Mr. S. S. Post, of New York, has designed an iron bridge for the Mississippi, at St. Louis, having 350 feet clear spans. This work was fully illustrated in "Engineering," July 24. The August 7th number of that journal gives the greater portion of the report of the "Committee on Superstructure and Approaches," at the Convention of Engineers, assembled at St. Louis, August, 1867. To this report figured diagrams for girders 368, 264 and 160 feet long were attached, solely to show the relative maxima of the strains to which the several parts of the girders are subject sometime during the passage of a given, irregularly distributed, moving load. To make the comparison a fair one, the girders were as nearly *similar* in their arrangement, and as uniformly divisible into panels as practicable. Assuming their bearing points to be two feet from the ends, the actual spans were 364, 260 and 156 feet, each of which is a multiple of thirteen feet. The figured diagrams happened to be arranged in consonance with Mr. Post's notions of economy in the use of materials, as exhibited in the design above mentioned. The bays or panels of the horizontal members of the girders were thirteen feet long, except that the chords had a half bay of six and a half feet at each end. The end posts were vertical, but the intermediate ones—the strut braces—were inclined *half a bay*. The heights of the respective girders were three and a half, two and a half, and one and a half bays, making the inclination of their struts one-seventh, one-fifth, and one-third of the height. The tie braces, except the end ones, were inclined 45°, and counter ties were introduced in each panel to the ends of the girder.

To this arrangement a writer in "Engineering" makes two principal objections. 1st. He thinks the counter braces are unnecessary, except "for a short length of the girder at its center"; and, 2d, on account of the particular inclination of the braces. On this latter point he says: "Another feature in the design challenges criticism. The diagonal ties are placed at an angle of 45°, and the struts at an inclination of one horizontal to seven vertical. Now, as we have already said, the useful work done by a strut or tie is the transference of the load towards the piers. It follows, from this, that a *vertical* strut is theoretically of no value at all; it is merely so much additional load on the girder. The load is just as far off its ultimate destination—the pier—when it is transmitted by the vertical strut to the bottom of the girder, as it was when at the top. An infinite number of vertical struts and ties, and, consequently, an infinite weight of metal so disposed, would not transmit the load to the piers. With the struts arranged as in the St. Louis bridge, the load is nearer the pier when transmitted through the strut, to the extent of one-seventh of the depth of truss, and with the ties at an angle of 45°, it is transferred by them a further distance equal to the depth. The question is, whether this total amount of one and one-seventh the depth, the distance which the load is passed on by each triangulation towards its ultimate destination, is as large as it should be. This problem is easily solved. From what has been already advanced, it will be seen that the most economical inclination of tie and strut will be that in which the cost of these members in one triangulation, divided by the horizontal length of same, is the minimum. The proper inclination of the tie and strut will be mutually dependent; with a different construction of strut the angle of the tie would also differ. If struts and ties were the same cost per foot to sustain the same strain, the proper angle would be 45° for both. As the strut is, however, always more costly than the tie, it follows that the economic angle for the tie will be more acute, and for the strut more obtuse than that angle. To determine the most economic angle for the truss we are criticising, we must approximate to the comparative costs of the wrought iron ties and cast iron struts. Assuming the average strain on the latter as one-fourth the amount on the ties per unit of area, and taking the cost per ton of cast iron as one-half that of wrought, we obtain the proportional cost of the strut, for each ton per square inch strain $\times$ one foot long, as double that of a tie under the same conditions. This is a very liberal allowance for the strut; in fact, on De Bergue's system they might be constructed in wrought iron for a considerably less amount."

"Now, if x = the horizontal distance between the two ends of the tie, and y = the same distance in the strut, the useful work done by each triangulation will be the transference of the load the distance $x + y$. Again, the cost of the tie will be proportional to its weight, that is, to the strain upon it multiplied by its length. But

the strain also is proportional to the length; hence the cost will be proportional to the square of the length, or in terms of the depth to $1 + x^2$. In the same manner the cost of the strut will be proportional to $2 + 2y^2$. The true measure of the economic value—the cost per foot—will, consequently, be proportional to $\frac{3 + x^2 + 2y^2}{x + y}$. It is only necessary, therefore, to determine the values of x and y when the preceding expression is the minimum. It will be found that $x = \sqrt{2}$, and $y = \sqrt{\frac{1}{2}}$; hence, the inclination of the tie, instead of being 1 to 1, as designed, should have been 1.4 to 1, and of the strut 0.7 to 1, instead of $\frac{1}{4}$ to 1. With the most economic inclination the cost of the web would be proportional to 2.86. With those adopted we obtain by substituting $x = 1$, and $y = \frac{1}{4}$ in the preceding equation, the cost of web proportional to 3.52, exhibiting an excess of some 23 per cent. With vertical struts the cost would be proportional to 4; hence the inclination of the struts, small though it is, effects a saving of 12 per cent. With the struts and ties all at angles of 45°, the cost would be proportional to 3, and the same result would be attained by arranging the ties at an inclination of $1\frac{1}{2}$ to 1, and the struts at $\frac{1}{2}$ to 1, so that considerable latitude is allowed for practical contingencies."

We give, below, the reply* of Mr. Post to the objections raised, and, we think, considering the ability of the parties to the discussion, that it will form an interesting as well as a useful chapter in bridge construction. Mr. Post believes the criticism to be in some respects just, but in other respects he regards the subject under a very different aspect from that assumed by the English writer. He says:

The doctrine that the transference of the weight of the structure and its variable load to the abutments can be accomplished only by means of inclined members, is fully admitted and needs no argument. It is also admitted that both the struts and the ties, connecting the upper and lower flanges, should be inclined. The Reviewer and myself differ somewhat as to the angle of inclination that ought to be given to the ties and to the struts. He will, undoubtedly, concede that acting *alone*, or in pairs, independent of any strut, the tie-brace will produce the greatest useful result when its inclination is 1 to 1, or 45° with a vertical.

Economy in the use of material in a brace requires that the quantity or volume should be the least in proportion to the distance spanned; that is, the greatest economy is when the volume divided by the horizontal reach gives the least quotient; or is a *minimum*. So long as the tie or strut remains vertical the quotient is infinitely great. It is then only an auxiliary, not a direct agent in the transference of the weight toward the abutment.

The strength of the tie depends upon its section, without regard to the length, neglecting its own weight. The section of the tie is always as the weight or stress in the direction of its length. The volume of the tie, when vertical, is proportionate to the product of the length into the weight suspended. When the tie becomes inclined, its length increases as the secant of the angle of inclination, and the stress also increases as this secant. When the maximum useful inclination is reached, this secant becomes $\sqrt{2}$, and the volume of the tie $l\sqrt{2} + W\sqrt{2} = 2\,l\,W$. That is, in passing from the vertical state to an inclination of 45°, the tie doubles its volume.

In the case of a strut, its volume conforms to a very different law in regard to its length and sectional area. Hodgkinson's formula for the strength of a cast iron cylindrical pillar, with rounded ends, and not less than 15 diameters in length, is

$$W = 33379 \times \frac{d^{3.76}}{l^{1.7}} \qquad (1)$$

in which $W =$ the breaking weight in pounds, $d =$ the diameter in inches, and $l =$ the length in feet.

Let $V =$ the volume in cubic inches of a pillar, the section of which is a circle; then

$$V = \frac{\pi}{4} d^2 \times 12\,l = 3\,\pi\,l\,d^2 \qquad (2)$$

From equation (1),

$$d^{3.76} = \frac{W l^{1.7}}{33379};\ d = \left(\frac{W l^{1.7}}{33379}\right)^{\frac{1}{3.76}};\ d^2 = \left(\frac{W l^{1.7}}{33376}\right)^{\frac{1}{1.88}} \qquad (3)$$

Substituting this value of d^2 in equation (2).

$$V = 3\,\pi\,l \left(\frac{W l^{1.7}}{33376}\right) = 3\,\pi \left(\frac{1}{33376}\right)^{\frac{1}{1.88}} \times W^{\frac{1}{1.88}} \times l^{\frac{1.58}{1.88}}. \qquad (4)$$

* "Engineering," Jan. 8, 1868.

$$V=0.036998\times W^{\frac{1}{1.88}}\times l^{\frac{2.88}{1.88}}. \quad (5)$$

From this it appears that the volume of a cast iron strut increases as the 0.35+ power of the weight imposed, and the 1.9+ power of the length.

Now, assuming the vertical height or altitude to remain constant, when the strut becomes inclined, its length increases and its stress also increases, both as the secant of the angle of inclination and its volume is greatly increased.

Putting V_1 for the new volume, m for the exponent $\frac{1}{1.88}$, n for $\frac{2.88}{1.88}$; $A=$ the coefficient 0.036998, $W=$ the weight, and $l=$ the altitude, as before, and make $x=$ the tangent of the angle of inclination, then $lx=$ the base or horizontal run of the strut, and $(l^2+l^2x^2)^{\frac{1}{2}}$ will be the length of the strut. $W\left(\frac{l^2+l^2x^2}{l}\right)^{\frac{1}{2}}$ will be the stress on the strut. Then (6)

$$V_1=A\times\left(\frac{W\sqrt{l^2+l^2x^2}}{l}\right)^m\times\left(\frac{l\sqrt{l^2+l^2x^2}}{l}\right)^n \quad (7)$$

$$V_1=A\times W^m\times l_n\times\left(\frac{\sqrt{l^2+l^2x^2}}{l}\right)^m\times\left(\frac{\sqrt{l^2+l^2x^2}}{l}\right)^n$$

$$V_1=A\times W^m\times l^n\times\left(\frac{\sqrt{l^2+l^2x^2}}{l}\right)^{m+n} \quad (8)$$

$$V_1=A\times W^m\times l^n\times\frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{l^{m+n}} \quad (9)$$

From this subtracting equation (5)

$$V_1-V=\frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{l^{m+n}} \quad (10)$$

is the increased volume of the strut in consequence of its inclination.

But by the condition of the question V_1 gives a minimum when divided by the base (lx), that is

$$\frac{V_1}{lx}=A\times W^m\times l^n\times\frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{lx\times l^{m+n}}=$$

a minimum.

$$\frac{V_1}{lx}=\frac{A\times W^m\times l^n}{l^{(m+n+1)}}\times\frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{x}$$

Suppressing the constant value $\frac{A\times W^m\times l^n}{l^{(m+n+1)}}$ and differentiating the variable function

$$\frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{x}.\ d\frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{x}=o$$

when the value is a *minimum*. Consequently

$$x^2\times(m+n)\ (l^2+l^2x^2)^{\frac{m+n}{2}-1}=(l^2+l^2x^2)^{\frac{m+n}{2}}$$

$$(m+n).x^2=\frac{(l^2+l^2x^2)^{\frac{m+n}{2}}}{(l^2+l^2x^2)^{\frac{m+n}{2}-1}}=l^2\times l^2x^2$$

$$(m+n).x^2-l^2x^2=l^2;\ (m+n-l^2)x^2=l^2$$

$$x^2=\frac{l^2}{(m+n-l^2)};\ \text{and}\ x=\frac{l}{(m+n-l^2)^{\frac{1}{2}}}$$

Putting $l=$ *unity*. $\quad x=\frac{1}{(m+n-1)^{\frac{1}{2}}}$

Restoring the numerical value of m and n and reducing them to the decimal form

$$x=\frac{1}{\sqrt{0.5319149+1.9042552-1}}=0.8344437,$$

which is the tangent of 39° 50½′ very nearly, and not 45° as in the case of the tie, and as the Reviewer asserts should be the angle of the strut also, if the cost for both were the same. The correct inclination of the tie when used without reference to a connecting strut is 45°, and the correct inclination of the strut, without regard to a connecting tie is 39° 50½′. But it unfortunately happens that the base of one is not a multiple of the base of the other. It is practically of great importance that all the bays of the top and bottom flanges should be of the same length. Floor beams and other laterals, of one pattern, can then be used for all the triangulations. Various other reasons can be given why the truss in this respect should be symmetrical, but they are sufficiently obvious. The cost of a strut, if made solid, will be much greater than if made hollow, but the theoretical angle of inclination will be the same in both cases.

Brevet Col. Wm. E. Merrill, U. S. Engineers, has obtained a very ingenious formula for the weight of a hollow cast iron cylindrical pillar of maximum strength for its volume. This formula is deduced from Hodgkinson's experiments. It appears to me to be very accurate, and although unpublished, I will take the liberty to use it here. It is

$$P=0.004599558\times W^{0.5319149}\times l^{1.9042553}$$

in which $P=$ the weight of the pillar in pounds; $W=$ the breaking weight in pounds and $l=$ the length in feet.

Suppose the height of the truss to be 45½ feet from center to center of the flanges (as in the case of the long span for St. Louis), and the panel weight 180,000 pounds. Suppose the tensile strength of a wrought iron tie is 60,000 pounds per square inch of its

sectional area. A vertical tie that will just break under this load, will have a section of three square inches, and weigh $45\frac{1}{2}+3+3.38=460$ pounds, very nearly. And a tie inclined 45° will have a section of six square inches and weigh 920 pounds. In both these cases the necessary enlargement at the ends for eyes or for thread and nuts is not included. The ends of the struts will also require enlargement for similar purposes, and as this enlargement will be nearly proportional to the whole weight in both ties and braces, they may here be totally neglected.

The weight of a vertical strut $45\frac{1}{2}$ ft. long, loaded with 180,000 pounds, will be

$$P=0.004599558\times(180000)^{0.5319149}\times(45.5)^{1.9042553}=4124 \text{ pounds.}$$

If the strut be inclined to its best theoretical angle of 39° $50\frac{1}{2}'$ its length will be increased 59.26 feet, and the stress to 234,444 pounds. Its weight will be

$$P=0.004599558\times(234444)^{0.5319149}\times(59.26)^{1.9042553}=7698 \text{ pounds.}$$

By making the inclination of the strut $\frac{1}{3}$, the length will be 47.96 feet, the stress 189,737 pounds, and the weight of the strut

$$P=0.004599558\times(189737)^{0.5319149}\times(47.96)^{1.9042553}=4676 \text{ pounds.}$$

Assuming the cost of wrought iron to be double that of the same weight of cast iron, the cost of the wrought iron tie, under an inclination of 45°, may be represented by $920\times2=1840$. The cost of the vertical strut will then be represented by 4124. The combined cost of the tie and strut will be $1840+41245=964$. Calling the horizontal run of the tie = the height of the truss = unity, then the economy in this case is represented by 5964. Taking the tie at an angle of 45°, and the strut at an angle of 39° $50\frac{1}{2}'$, the economy of their combined use is

$$\frac{1840+7698}{1.834437}=5145.$$

In this case, where both the tie and strut have their theoretic angles, there is a saving of only 16 per cent. over having the strut vertical, and a saving only $\frac{1}{3}$ greater than is admitted by the Reviewer when the inclination is $\frac{1}{1}$. When the inclination of the strut is $\frac{1}{3}$, and the tie $\frac{1}{1}$, the economy of their combined use is represented by

$$\frac{1840+4676}{1\frac{1}{3}}=4812,$$

showing a saving of nearly 24 per cent. in the cost.

The pamphlet containing the description of the truss under review, also contains the description of other trusses proposed, in some of which the inclination of the strut brace is $\frac{1}{3}$, in some others it is $\frac{1}{2}$, and in others it is $\frac{1}{1}$ the height of the truss. Nowhere is it pretended that either of these inclinations is theoretically correct, but each one, under the circumstances attending its use, is *practically* the *best* that could be given it. When a tie can be used at an angle of 45°, I do not quite comprehend the philosophy of abandoning what is absolutely its best position because a contiguous strut cannot assume *its* best position also.

From the vertical to an inclination of 39° $50\frac{1}{2}'$, the cost ranges from $2\frac{1}{4}$ to $4\frac{1}{5}$ times the cost of the tie inclined 45°; of course the expression $\frac{3+x^3+2y^3}{x+y}$ does not apply to the case, and all deductions therefrom fall.

The relative cost of struts inclined at various angles, coupled with a tie at 45°, will be considerably modified by the difference that may be made between the ultimate strength and a safe working strength. If 6 be introduced as the factor of safety, the cost of the wrought-iron will be increased to six times, while that of the cast-iron will be increased to only $6^{0.53+}=2.5937$ times.

The relative cost will then be for tie 45°, and

Strut *vertical*,

$$\frac{1860\times6+4124\times2.5937}{1}=11040+10596=21636.$$

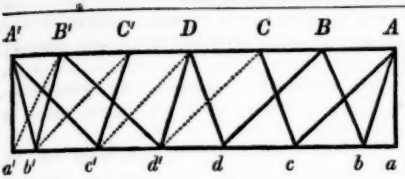
Strut inclined 39° $50\frac{1}{2}'$,

$$\frac{11040+17966}{1.83444}= \quad 15766.$$

Strut inclined $\frac{1}{3}$.

$$\frac{11040+12128}{1\frac{1}{3}}= \quad 12376.$$

That an American engineer should act upon a theory different from that long held on the other side of the Atlantic, as to the value or usefulness of counter braces (so called), seems to excite the most surprise in the mind of the Reviewer. He asks, "Upon what hypothesis are the computed strains on the counter braces based?" In answering this question reference is made to the following diagram:



The strains upon this girder resulting from the permanent load, or from one-half the weight of the bridge itself, are symmetrical about the middle point *D*. Of course the opposite halves are perfectly balanced, whether the girder be composed of the finest steel or of the coarsest lead. The weight of the structure may be assumed indefinitely small or indefinitely great. In either case any accidental load will disturb the balance. Let *W* represent a panel weight of this permanent load, whatever it may be; then the portion of the permanent load transferred to the abutments (*a a'*) by the inclined braces will be, by

B d and *B' d'* each *W*, and the strain will be $W \times$ Sec. $\angle$.

A c and *A' c'* each W, and the strain will be $W \times$ Sec. $\angle$.

A b and *A' b'* each $1\frac{3}{4}W$, and the strain will be $1\frac{3}{4}W +$ Sec. $\angle$.

Under such a condition there can be no *use* for counter braces, represented by dotted lines in the left hand half of the diagram.

Now, supposing the variable or moving load, consisting of a very heavy engine, occupying the length of two panels, followed by its tender and a train of cars, be brought upon the bridge from the left—

Let $e =$ a panel weight of the engine per truss;

Let $t =$ a panel weight of the tender, and

Let $c =$ a panel weight of cars.

On arrival of the engine at *b'*, that point receives a special load $= \frac{3}{4}\,e$, which is not balanced by a corresponding load at *b*. A new state of equilibrium in the truss instantly occurs. Of this additional weight $\frac{1}{12} \times \frac{3}{4}\,e = \frac{1}{16}\,e$ has been transferred to *a*, and $\frac{11}{12} \times \frac{3}{4}\,e = \frac{11}{16}\,e$ has been transferred to *a'*. The result would have been exactly the same if the train had entered from the right, only that of the special weight now at *b*, $\frac{1}{12}$ would be transmitted to *a'*, and $\frac{11}{12}$ to *a*.

Through what channels is the transference of the lesser weight made in the two cases? It seems to me that when the moving load enters from the left, the tie *C' b'* will be *used* for this purpose; but the load coming from the right, it is certain that where no tie *C b* exists, it is of *no use*. How, then, when the moving load comes from the right, is the weight $\frac{1}{16}\,e$ transmitted from *b* to *a'*? Is it not *first* by tension on the strut *B b*; *second*, by compression on the slender tie *B d*; *third*, by tension on the strut *D d*, when having reached the centre point *D*, which it would also have reached by way of counter braces, it then pursues its legitimate course to *a'*.

How, it may be asked, supposing the strut *B b* to be removed so as to close this channel of communication, is the $\frac{1}{16}\,e$ to be transmitted to *a'*? If the corresponding strut (*B' b'*) at the other end were also removed, there would obviously be a collapse. Perhaps the horizontal force $\frac{11}{16}\,e$ may contain in a latent state the transmitted weight $= \frac{1}{16}\,e = \frac{3}{4\,8}\,e$ of vertical force, which is set free on the first opportunity by reaching the next inclined member (*C c*). However this may all be, $\frac{1}{16}\,e$ must be transferred from *b'* to *a'*, and it is not easy to conceive in what way the weight of the structure itself can influence this transference. Undoubtedly the simplest means of transferring this $\frac{1}{16}e$ from *b'* to *a'*, would be by inserting a tie from *b* to *A'*, but the arrangement of the parts of the girder forbids. The simplest practical means left is to insert ties tending in the desired direction.

To return to the effect of the moving load entering the bridge from the left: when the engine has reached *b'*, $\frac{3}{4}$ of a panel weight of the engine will rest at that point, $\frac{11}{12}$ of which will be supported by the tie *A' b'*, and $\frac{1}{12}$ transmitted towards *a*. Now, if a tie exists from *b'* to *C'* tending in the direction the weight is to be transferred, and if this tie be more direct than any other inclined member, the $\frac{1}{16}\,e$ will inevitably take such route. All the ties parallel to *C' b'* will be equally affected by the $\frac{1}{16}\,e$.

The partial load at *b'* $= \frac{3}{4}\,e$, is divided into $\frac{11}{12} \times \frac{3}{4}\,e = \frac{33}{48}\,e$, which is sustained by the tie *A' b'*, and $\frac{1}{12} \times \frac{3}{4}\,e = \frac{3}{48}\,e$, sustained by the tie *C' b'*.

The horizontal force developed in the horizontal tie *b' c'* is $(\frac{1}{3} \times \frac{11}{12} - \frac{1}{12}) \times \frac{3}{4}\,e = \frac{8}{48}\,e$ and in the tie *C' b'* $\frac{3}{48}\,e$, assuming always that the long ties have an inclination of 45°. Then the strain on the tie (*C' b'*) at a certain moment is $\sqrt{2} \times \frac{3}{48}\,e$. This is a *positive* strain, and no weight or inertia of the structure can relieve it. The numerical results of this strain can be given "to the smallest fraction" when a numerical value for *e* is assumed. It is the *maximum* strain. It does not become *negative* because the per-

manent weight of the bridge acts against it, as assumed by certain writers.

The maxima of strains at any time affecting the several ties while the train passes the bridge will be—

On B' a' nothing.
On C' b' $\sqrt{2}\times(\frac{1}{12}\times\frac{3}{4}e)$.
On D c' $\sqrt{2}\times(\frac{3}{12}e+\frac{1}{12}\times\frac{3}{4}e)$.
On C d' $\sqrt{2}\times(\frac{5}{12}e+\frac{1}{2}\times\frac{3}{12}e+\frac{3}{4}\frac{3}{8}t)$.
On B d $\sqrt{2}\times(W+e+\frac{3}{24}t+\frac{3}{8}\frac{3}{6}c)$.
On A $c\sqrt{2}\times(W+\frac{9}{12}e+\frac{5}{12}t+\frac{1}{8}\frac{5}{6}c)$.
On A b $\frac{1}{3}\sqrt{10}\times(1\frac{3}{4}W+\frac{11}{12}e+\frac{7}{12}t+\frac{1}{8}\frac{3}{6}c)$.

Here it is found that the computation of the maximum strain in the several ties is a problem "capable of the most rigid solution," notwithstanding the strains on contiguous braces vary so considerably in the gross amount. When the material of these braces and of all the other parts is properly proportioned to meet the strains, the bridge may be considered in its normal condition, at least so far as the transmission of loads in the early lifetime of the bridge is concerned.

We have been informed, on the authority of such men as Eaton Hodgkinson, W. Cubit, Geo. Rennie, Henry James, Robert Willis, and Lord Wrottesley, that upon an iron bridge of 48 feet span an engine and tender weighing 39 tons, at a speed of 50 miles per hour, in consequence of the bridge having a static deflection of $\frac{1}{5}$ inch, the speed increased the deflection $\frac{1}{4}$, or to what would be due to a weight of about 45 tons. If, then, a slight static deflection causes the moving load, under a velocity that is not unusual, "to exercise the same pressure as if it had been increased by $\frac{1}{4}$, and placed at rest upon the centre of the bridge," I do not see, with the Reviewer, that "an inch more or less is a matter of no moment at all in the deflection."

The maximum variable load carried by the tie B' d' and by the strut B' b' is $(e+\frac{3}{24}t+\frac{3}{8}\frac{3}{6}c)$.

Under this variable load more or less deflection occurs at b'. If, now, the tie B' a' be inserted and screwed up to the slightest degree of initial tension, not so as to increase the pressure on the strut, when the engine passes off the bridge, the strut B' b' must remain under the same pressure as before, in consequence of its reaction on the tie B' a'.

Bringing the engine back to d', the tie B' d' is again loaded, and the tie B' a' relieved. No change in the deflection at b', nor difference in the pressure on the strut has occurred. On this principle the strains on the counter braces for the bridge at St. Louis were computed. If it were possible to construct a bridge perfectly level and straight, so that it would have no static deflection, whether loaded or unloaded, its dynamic deflection, however great the speed, must be very little.

In calculating the strains upon the St. Louis bridge, the moving load was not considered as uniformly distributed, consequently the maximum strains on the flanges do not occur at the middle of the span. Hence, $28\times61635=1.725780$ pounds, is not the correct maximum strain on the top flange. It cannot, therefore, be fairly inferred from such a calculation that some initial strain is assumed on the counter braces when the bridge is fully loaded, nor that the condition is such as "involves the provision of greater strength in the diagonal struts and ties than is absolutely required for the useful duty they have to perform."

STEEP RAILWAY GRADIENTS.

At the present time, when attention is being again directed to the unsatisfactory working of the Mont Cenis engines with their horizontal gripping wheels and attendant complications, it is worthy of note that during the construction of the Ottoman railway, Mr. T. R. Crampton made regular use of, and worked by an ordinary contractor's engine, a tramway laid for a length of 800 yards to a gradient of one in eleven. This tramway was altogether about a mile long, and for 800 yards of this length it rose, as we have said, at an inclination of one in eleven, afterwards descending for about the same distance with inclines of one in fifteen and one in twenty. About 200 yards of the gradient of one in eleven consisted of curves of 400 feet radius. The tramway was employed for the conveyance of materials to be used in the construction of the main lines, and during six months about 10,000 tons were carried over it. It was worked by an ordinary contractor's locomotive, built by Mr. Hughes, of Loughborough; this engine having cylinders eleven inches in diameter by eighteen-inch stroke, and two pairs of coupled wheels two feet six inches in diameter, placed four feet six inches apart from centre to centre. The weight of the engine in working order was ten tons, and it drew behind it a load of thirteen tons up the gradient of one in eleven. The pressure of the steam was from 90 pounds to 100 pounds per square inch.

On an incline of one in eleven, the resistance due to gravity would be 203.64 pounds per ton, and taking the engine friction at eighteen pounds per ton, and the wagon friction at ten pounds per ton, we have the following total resistance to be overcome by the engine in ascending the gradient:

	Pounds.
Resistance due to gravity: 23 tons at 203.63 lb. per ton	4,683.5
Engine friction: 10 tons at 18 lb. per ton	180
Wagon friction: 13 tons at 10 lb. per ton	130
Total	4,993.5

or, say, 5,000 pounds. The weight available for adhesion was ten tons, or 22,400 pounds, which would be diminished by one-eleventh on an incline of one in eleven. The actual adhesion weight available in the incline would, therefore, be—

$$22{,}400-\frac{22{,}400}{11}=20{,}364 \text{ lb.},$$

and the adhesion must, therefore, have amounted to very nearly one-fourth of the load on the wheels. An engine of the dimensions above given would develop a tractive force of—

$$\frac{11^2\times1.5}{2.5}=\frac{121.\times1.5}{2.5}=72.6 \text{ lb.},$$

for each pound of effective pressure per square inch on the pistons; and to overcome the tractive pressure of 5,000 pounds, this effective pressure must thus have been $\frac{5{,}000}{726}=68.6$ lb. per square inch. This pressure on the piston could, of course, readily be maintained by a boiler pressure of 90 pounds per square inch.—*Engineering.*

ROMAN MORTAR.—The Roman mortars were essentially different from ours; they were composed, with a few exceptions, of pure lime mixed in large proportions with fragments of bricks coarsely pounded. This mortar formed the bottom and side lining of cisterns, fish-ponds, aqueducts, &c. Probably the introduction of the dry substances was for the purpose of hastening the solidification by exhausting the superabundance of water from the lime. Thus, probably, the desiccation of the mortar was obtained and its compactness and impermeability to water secured. The lime, sand, and brick of these mortars were those of the country where the structures into whose composition they enter now exist.

PHOTOGRAPHY.

PICTURES OF THE ECLIPSE—PERMANENT PHOTOGRAPHS.

From the "Mechanics' Magazine."

The total eclipse of the sun, visible last August in equatorial Asia, has called special attention to astronomical photography, and this branch of the science will doubtless be considerably improved before it is brought to bear next August upon another total eclipse, visible throughout a large portion of the United States. The recent photographic operations of the English expedition to India proved a failure, because of the want of a skilled photographer upon the staff. The plates were spoilt, because of the drying of the silver solution upon their surfaces, and they were all under-exposed. The first of these mishaps may always be avoided, and the German expedition at Aden avoided the latter by trying some experimental plate shortly before the totality, to get some clue beforehand to the decline in the actinism of the light produced by the eclipse. Next year, more pictures may be obtained in the same space of time, by adopting the plan of the Germans at Aden, of taking two pictures of the eclipse upon one glass plate. This is done by a simple plan well known to photographers. The sliding dark back, carrying the plate, is lengthened, so that after one picture is taken, and the light cut off, the slide is moved onwards two or three inches, and another picture taken upon the same film. This plan saves half a minute, or more, which otherwise would be lost in changing the slides.

The English apparatus worked capitally during the eclipse, but even in this the German expedition had one slight improvement. The photographic part of their apparatus was not directly fixed to the tube of the telescope, lest the necessary motions of the slides should set up vibrations, so the connection was made by means of an india-rubber tube, which also excluded all stray light. In ordinary photographic operations, if the operator desires to get the maximum number of negatives in the shortest space of time, he not only furnishes his camera with a long sliding back, but he increases the number of his lenses, to throw several similar pictures upon different parts of the same sensitive plate. This raises the question whether in photographing solar eclipses it may not be possible to mount two or three reflectors or refractors at the end of a single

telescopic tube, so that, say, three pictures are thrown at once upon the plate in a vertical line one above the other. Then, by shifting the plate as already described, six pictures would be obtained upon one film; or, by a second motion of the plate, even as many as nine might be impressed.

Many plans for increasing the permanency of photographic prints have been under consideration at the various societies during the past year, but the results, as regards pictures upon albumenized paper, have been small. The very few photographers who are really scientific men, turn out silver prints which in comparison with the general run of such pictures, are stable, fresh and good, hypo-sulphite of soda solution, and thorough washing of the prints after fixing, being the best guarantees of permanency. After the washing and mounting of such pictures, rolling and waxing seems to increase the stability, by the production of a print with a hard glazed surface, somewhat protected by the wax from deleterious impurities in the air. But no care in silver printing upon albumenized paper seems to give security against fading in the long run, and no photographic chemist of eminence would risk his reputation by the assertion that any such silver pictures are as durable as engravings in printing ink. Messrs. Disderi, Johnson, and others, have been producing some very delicate and beautiful prints upon wet collodion, which prints were afterwards transferred to paper. Little or nothing is as yet practically known about the durability of these pictures, but theoretically there are reasons for supposing that they will last longer than the common kind. At all events, they are more pleasing and engraving-like in appearance, and can be turned out at the same price as their better-known rivals.

Carbon was the basis of the best and most imperishable of the inks in use by the monks of old, and there is no doubt that the most permanent photographic pictures at present obtainable upon paper are those produced by the carbon process. Mr. Joseph Swan first produced these pictures upon a commercial scale, and after working the process up to a great state of perfection, he recently sold his patent for a high sum to a London Company, but there is scarcely a phhotographer in London who will undertake to supply carbon portraits on any terms whatever. One of the best and certainly one of the most beautiful kinds of permanent photographic pictures are transparencies upon collodion, cemented between two sheets of glass with Canada balsam. The balsam in its natural state will not do, as the essential oil it contains gradually evaporates, and at last the picture ceases at places to remain in optical contact with the glass. This essential oil should first be driven off by heat to such an extent that the balsam hardens as it cools, and this hardened balsam should be used in cementation processes. Even this, in some cases, tends to become brittle with age, whereby the plates have a liability to split asunder too easily, so that experiments are desirable to ascertain the best substance to mix with the balsam to increase its toughness.

This question of durability of photographs is of far more national interest than is apparent at first sight. If photography had been known in the days of Queen Elizabeth, and the photographers of that time took nothing but fading pictures, so that that the London life of the period was thereby pictorially lost to us for ever, except in the imperfect wood cut and flattered oil portrait, what censure we should now heap upon the photographers of old. Yet the photographers of to-day stand a good chance of falling into similar disrepute in the opinion of posterity. Month by month the physical features of all our cities are changing with great rapidity. Railways are cutting up the old streets and new streets are being cut through in all directions. Little is thought of these changes at the time they are made, but after the lapse of a few years, accurate pictures of our cities as they used to be, will begin to grow in public interest.

THE BESSEMER PROCESS.

PIG IRON—BLAST AND BLAST PIPES—RECARBURIZER.

From "Engineering."

In the practical management of a Bessemer steelworks the selection of pig iron is one of the most important questions. It is well known that the percentages of silicon, carbon, manganese, sulphur, phosphorus, and copper, must all correspond to certain figures ascertained by experience, or must at least remain within certain very narrow limits, in order to insure a complete reliability and regularity of practice and a high quality of the metal produced. The percentage of silicon should not be below 1 per cent., and not above 2 per cent.; the percentage of carbon should never be below 3 per cent.,

but ought to be as high as possible. The presence of manganese to a certain extent replaces that of carbon; but the pig iron charges should not contain more than 3 per cent. of manganese, because the great affinity of manganese for oxygen causes a very violent action in the converter, resembling a series of explosions, by which a great quantity of metal is thrown out of the vessels. Silicon is an antidote against this violent action of manganese, and a charge of manganesic pig iron, mixed with a suitable proportion of pig iron, containing about 3 per cent., or 3.5 per cent. of silicon, works quietly, and gives an excellent product. In a similar manner it is a very advantageous practice to mix pig iron which is overcharged with silicon with a proportionate quantity of spiegeleisen in making up the charge for the converter. The charge requires at least 2 per cent. of manganese for every per cent. of silicon which it holds in excess of the requisite quantity, say $1\frac{1}{2}$ per cent. When the pig iron is melted in an air furnace the percentages of carbon, silicon, and manganese are sensibly diminished by the ordinary influence of the flame; this effect, to a certain extent, depends upon the management of the melting furnace, and the attention of the operator should be directed to the prevention of an excessive oxidation in the air furnace. When a cupola is used for melting the pig, or when the pig iron is run direct from the blast furnace into the converter, the proportionate quantities of carbon, silicon, and manganese named above may be slightly reduced.

The distinction which is made between combined and uncombined or graphitic carbon, when judging of the applicability of pig iron for the Bessemer process, is a prejudice. The total percentage of carbon, both combined and uncombined, is the only criterion, as far as the applicability to the Bessemer process is concerned. Sulphur, phosphorus, and copper are limited to the extremely small percentage of 0.05 per cent. whenever a high quality of metal is to be produced. From this it does not, however, follow that no pig iron which contains a higher percentage of either of those three impurities can be employed with advantage. By mixing different kinds of pig iron in a judicious manner, it is possible to dilute the impurities, and bring them down to the normal percentages. In making up a charge from three different kinds of pig iron, for instance, one-third of the charge holding 0.15 per cent. of sulphur, the second contaminated with phosphorus to the same extent, 0.15 per cent., and the third part of the charge containing 0.15 per cent. copper, it is obvious that the mixture of liquid iron charged into the converter comes within the limits named above, and is perfectly suitable for the production of the best qualities of Bessemer metal, although none of the classes of pigs from which that charge was made up could have been by itself employed for the Bessemer process.

The pig iron, when selected and made up into a charge, should be melted rapidly, and at the highest temperature which can be produced. The runners or channels through which the iron passes into the converter must be of large sectional area, and carefully dried and heated previous to tapping. The converter must have a full white heat before receiving the charge, and the liquid iron must be run into it as rapidly as is compatible with safety and cleanliness. The converter should never be turned up before the safety valve upon the air vessel has commenced to blow off, and the blast is let on full before the converter is brought into an upright position. The liquid column of iron in the converter is from 12 to 14 in. deep. This depth is not exceeded in the converters of larger sizes, which have a larger diameter and a correspondingly greater number of tuyeres, so as to hold the greater quantity of metal without increasing the depth of the ferrostatic column. The blast pressure in the air vessel varies from 12 to 25lb. on the square inch, and it is never less than three times as great as the weight of the liquid column which rests upon the tuyeres. This shows that the back pressure caused by the liquid column bears only a comparatively small proportion to the total sum of resistance presented to the passage of the blast through the Bessemer apparatus.

The resistance which the blast must overcome in passing through the converter is made up, first, of the friction and other loss of power in the pipes and passages between the air vessel and the tuyere box; second, of the friction and resistance caused by the numerous and narrow holes of the tuyeres; third, of the head of liquid column covering the tuyeres and the friction within the liquid metal; and fourth, of the friction and resistance caused by the contracted flue or mouth of the converter. The sum total of these resistances offered to the blast in passing through the vessel is measured by the pressure gauge, on the platform, and it is

obvious therefore that the variations of pressure, as indicated by the gauge, do not of themselves show to which particular item any fluctuations are due. The burning and shortening of the tuyeres may lessen the friction, or the partial choking reduce the area of passage; the iron may become more or less fluid; the throat may be partly filled with slags, and thereby reduced in area; or a leak in the pipes may cause a loss of air pressure: all these and many other causes, which by their simultaneous action interfere with each other's individual effects upon the pressure gauge, make the indication of that instrument more or less confused and difficult to understand. It is preferable to look to the behavior of the converter instead of to the indications of the pressure gauge in controlling the blast pressure during the charge. The speed of the gaseous current must be so great that the flame which rushes out of the converter maintains a clear and well defined outline and a steady position. If the flame begins to waver or oscillate laterally, it is always considered as a sign of insufficient blast pressure. An excess of blast pressure is attended with violent and very voluminous eruptions of slag and metal from the vessel, and it can be easily remedied by allowing a portion of the blast to escape from the main pipe. This is preferable to throttling, because it does not throw any sudden back pressure upon the blowing engine, and allows the latter to keep up its speed with uniformity. An accident which occasionally happens in blowing a Bessemer charge is the cracking of a tuyere. If this takes place during the earlier part of the process the vessel may be safely turned down, and the metal will remain fluid while a fresh tuyere is inserted. If the accident happens during the later stage of decarburization the danger of setting or solidifying is much greater, but there is still a possibility left to to save the charge by skilful management. The vessel is turned down for a second, and this allows the liquid steel which fills the crevices of the cracked tuyere to solidify, and choke the escape passage or leak. The vessel is then tight for another minute or half of a minute, after which time the process must be repeated. It is possible to repeat such an operation three of four times, and the few fractions of minutes thus gained may be sufficient for completing conversion of the charge.*

The most important and at the same time the most difficult part in the management of a Bessemer charge, is the determination of the precise moment when the charge is completed, and where the vessel must be turned down for receiving the final dose of spiegeleisen. When the flame is clearly visible at the end of the charge, there is no difficulty in recognising a sudden change of its color and appearance after a short practice; but some qualities of iron evolve such masses of dense smoke of red, white, brown, or yellow color, that the flame is completely covered, and the changes in it are very difficult to observe. The spectroscope, the slag-test, and similar other contrivances, are then brought into requisition with more or less success; but fortunately these inconvenient kinds of iron form the exception, and not the rule, amongst the pig iron which is applicable to the Bessemer process.*

The purpose and intention of the final addition of spiegeleisen is to remove the surplus oxygen from the metal which may have remained in it after complete decarburization. The elements by which we can remove oxygen from iron are carbon, silicon, and manganese. Of these silicon has the important advantage that it forms no gaseous combination with oxygen, and therefore causes no ebullition in the ladle and in the moulds. Against this there is the great danger of overcharging the steel with the silicon, which may be added to it in excess of the precise quantity required for the removal of the oxygen. The consequence of such an overcharge would be hardness, brittleness, and want of elasticity in the steel produced. Carbon and manganese form gaseous combinations with oxygen at the high temperature existing in the converter; the ebullition in the ladle and moulds is therefore not easily avoided when these elements are used for removing the oxygen, but the surplus of carbon left gives

* The giving way of the lining around a tuyere or the burning away of a tuyere, are of more frequent occurrence. We have seen a four ton vessel turned down 55 minutes within five minutes of the completion of the blowing, and the charge saved, but of course very cold, and sculling in the vessel and ladle. We have turned down nine times within fifteen minutes, and saved the charge. If the metal runs through a small hole, and sufficient *time* is taken to chill it in the hole, a charge may be generally saved. But the forcing up of a wet bottom by the steam formed in it, and any large hole in a thin part of the lining, are remediless cases. The metal in the converter must then be cast into pigs, if possible, as if partially blown it will stick to and destroy the cast iron ingot moulds.—Ed. Van Nostrand's Magazine.

* But one of some hundred kinds of pig iron with which we have experimented in this country, has given an uncertain indication of decarburization.—Ed. Van Nostrand's Magazine.

the required hardness to the steel, and any surplus of manganese remaining in the steel is comparatively harmless as regards the quality of the product. When silicon is present the manganese is less liable to cause ebullition, since it can form a liquid slag, or silicate of manganese. For these reasons the final addition to the Bessemer charge should contain the three elements, carbon, silicon, and manganese. There should be a surplus of manganese to allow for the uncertainties regarding the quantity of oxygen left in each charge; there should be no more silicon than is required to form a slag with the greater portion of the oxide of manganese; and there should be no more carbon than is needed for finally carburizing the charge of steel. The natural spiegeleisen, as a rule, is too poor in manganese, and too rich in carbon to produce this effect, and when steel is made by its application it is difficult to produce a very soft quality. Mr. Henderson's ferro-manganese, which contains from 20 to 30 per cent. of manganese combined with 5 per cent. of carbon and a small quantity of silicon, is a substance of much greater value for the production of the highest qualities of soft steel; and the mode of manufacturing such artificial alloys affords a possiblity of bringing the relative quantities of the elements to almost any desired proportion.

The spiegeleisen should not be kept in the furnace for any length of time, as it loses its manganese and silicon by oxidation. It should run into the converter with great speed, so as to enter into the liquid charge with a certain momentum. This prevents its collecting upon the surface of the decarburized iron, which has a greater specific gravity than spiegeleisen or ferro-manganese. It is not necessary to turn up the converter a second time after the final addition, since an immediate reaction takes place, and a large white flame rushes out of the converter although the blast is entirely shut off. The liquid steel is then immediately poured into the ingot moulds. Only in the exceptional case, when there in no flame visible at the converter mouth after the addition of manganese, the vessel must be turned up a second time, and the blast passed through it for a few seconds. This is done because the absence of a vivid reaction indicates that the charge had not been blown long enough at first, so that there was no surplus oxygen left in it, and the additional time of blowing is required for removing the surplus of deoxidizing elements added at the end of the charge.

CHEAPER RAILWAYS AND WORKING.

The British newspapers, professional and commercial, are discussing this subject very earnestly. It is important to us in America, however, that we should not be led astray by names. The cheap and light railways advocated by Englishmen, are by no means to be deprived of the best known systems of drainage, ballasting, rails, rail jointing, rolling stock and power. Indeed, it is proposed to increase the weight of rails, and a great economy is expected from articulating engines and trains at a considerable extra cost. British engineers propose to cheapen railway construction chiefly by *avoiding heavy earthworks and costly works of art, and by filling the trains.* It is proposed to go over and around hills rather than through them. The cost of steam power on gradients and of wear and tear on curves, is less than the interest on the works necessary to avoid gradients and curves, within reasonable limits. The American system may be followed to advantage, in this particular.

But in respect of stations, the American system is equally wrong—in the other direction. Our traveling public is incommoded, disgusted and led to avoid railways rather than accommodated and encouraged to travel by them. A railway station need not be a palace, but Paddington stations at West Philadelphia, Albany and Baltimore, for instance, and a St. Pancras in the upper part of New York, with overhead or underground downtown branches, would pay better than the cramped disagreeable and unsafe sheds that now incommode the great traffic of these localities. In the matter of carrying tons of non-paying load to pounds of paying load, the English system of compartments, and guards paid to keep them empty,* is as bad as possible. Now that our own system of one fare and one class thoughout is modified by the introduction of sleeping berths, sitting-rooms and other accommodations specially (and roundly) paid for, it may well be studied abroad. The transportation of non-paying load however, is a very serious evil everywhere; there is no really good practice to copy, and the whole department requires reorganizing on a radically new plan. The following considerations on this subject

* English express trains are very heavy, very fast, and very frequent, and they are rarely well filled. A few shillings to the guards and porters will purchase accommodations that cost the railway company many times that amount.

are compiled from various numbers of "Engineering" and from the "Railway News":

Railway transport in itself is a very profitable business, yielding from 50 to 60 per cent. of gross receipts in the shape of profits. These handsome profits have, however, been rarely if ever realized for the benefit of those who have invested in the undertakings, for previous to the distribution taking place a host of parasites have to be provided for. The seven lean kine which eat up so large a share of the profits of railways are: Unnecessary expenditure in preliminary and parliamentary proceedings; excessive payments for land; excessive cost of construction; unremunerative expenditure upon branches; duplicate lines and improvements upon original line by short cuts and otherwise; cost of financing and jobbery connected with formation of company, issues of securities, and construction contracts; and accumulations against capital account of dividends paid, but not fairly earned. By way of illustration in a line now being constructed by the Midland Company, running parallel with a line belonging to the Great Western, there is no difference whatever in the formation or the nature of the work; but the same length of line which cost the Great Western Company one million is now being constructed by contractors for two hundred thousand pounds, or just one fifth! In the case of the Brighton Company, the committee of investigation specified twelve branches which did not pay working expenses, much less any return for interest on capital.

The interests of a small community of shareholders and bondholders, who have wasted their money in a railway are not to be considered against those of many millions of people who are made to pay for the waste. Were every corn-mill and every bakery in the kingdom built of such costly materials, and of such needless dimensions and such elaborate architecture, as to have cost twice what it ought, this would be no excuse to the public for demanding of them twice the present price of bread. For all the great necessaries of life—food, drink, clothing, firing, lighting, the means of transport, etc., the necessary cost of which is known—the public will demand and ultimately enforce the supply at that cost, including a fair profit upon only the *necessary* capital employed.

It has been too long the habit to regard the mere cost of traction as the chief element of railway expenditure, whereas *the* great item of expense is interest upon capital—not of course that interest or dividend is always paid, although it is not the less chargeable in default of payment. To pay the interest on the whole cost of the present lines requires a charge in the way of fares and freights at least twice greater than the present total working expenses. Of the latter, locomotive power, repairs and renewals of rolling stock, and maintenance of way, which alone are influenced by gradients and curves, do not form much more than one-half, the remainder going in management, train and station service, rates, taxes, Government duty, etc. In other words, nearly or quite three-fourths of what the public now pay to the railways is absorbed in expenses and in payments upon capital not in themselves influenced by the steepness of gradients or the sharpness of curves. Again, taking the expenses which are so influenced, it is certain that very considerably steeper gradients and shorter curves may be introduced, here and there, to save costly works, without increasing the cost of locomotive power and the outlay for wear and tear by more than a very moderate percentage. If this increase did not, as it hardly would, exceed five per cent., and the new line cost but half as much per mile as the old, then for every pound now paid by the passenger, very nearly five shillings would be saved to him while paying the same rate per cent. of profit upon the railway capital as now. If, by the outlay of £1,000, a clear saving of £50 can be effected yearly in working expenses, the outlay is justifiable, but if £100,000 are spent to obtain theoretically favorable gradients or curves which do not really save £1,000 yearly in working expenses the outlay is a wasteful one. If this extra outlay be made upon a single mile of line, as upon a costly viaduct, or a tunnel, the interest upon it at five per cent. is 1,200,000 pence per annum, equal to £13 14s. per day, and equal to nearly 7s. per train for each of forty trains running daily over that mile for 365 days in the year. Taking the number of trains at a more reasonable figure, say, twenty daily in both directions, it is evident enough that the cost of working a comparatively steep incline half a mile long, the adoption of which would avoid the necesssity for a costly tunnel or viaduct, could be nothing like 14s. per train above and beyond the necessary cost of working a level.

SEWAGE.

OLD AND NEW SYSTEMS—REQUIREMENTS, CAPACITY AND VENTILATION OF SEWERS — APPLICATION OF SEWAGE TO AGRICULTURE—PURIFICATION OF SEWAGE.

Compiled from M. Mille's account of the Paris Sewage, Chief Engineer Hermany's report on Memphis Water Works, "The Engineer," "The Builder," The report of Messrs. Bateman and Basalgette on the Glasgow Sewage, &c.

The complete removal of sewage, not only from towns, but from the waters and even from the vicinity of large towns, is one of the most vital and urgent questions of the day. The health of millions and the lives of thousands of human beings depends upon it. In the older towns of Europe, it is perhaps the foremost engineering as well as sanitary problem. In the larger American towns, especially those that are not traversed or surrounded by great volumes of natural tides or currents to dissipate and dilute the sewage, the necessity of disposing of it by artificial means is felt and acknowledged. But unlike the greater number of works for the public protection, such as fortifications, docks, fire departments, &c., which return no revenue, sewage works properly constructed, are *commercial and manufacturing investments*, as much so as the importation of guano or the preparation of the Charleston phosphates. Besides being indispensable to the healthfulness of all towns, and even the habitableness of some, sewage works may be made to pay directly, in the wonderfully increased productiveness of lands to which the refuse matter is applied. Even in cities like New York, this view of the case cannot long be ignored. Although New York is surrounded by a volume of water that dilutes and appears to dispose of its sewage, great banks of this material are already found in all its slips and beneath its waters—foul banks that are even now reservoirs of disease, and will one day spread pestilence along its shores, instead of directly contributing to its health and wealth, by cheapening and so bettering the food of its people.

ANCIENT SYSTEMS.—In ancient Rome the *cloaca maxima* carried the whole refuse liquids of the city into the Tiber, as was the case with the Thames not long since. The Arabs introduced irrigation into Europe, and the practice spread gradually along the western coast of the Mediterranean. In the thirteenth century, at the time of the Christian conquest, the plain of Valence was watered by seven branches of the Xucar, and in the town the sewage of the houses was conveyed through earthen pipes, or brick conduits, into open sewers. As the population increased infection became serious, and the conqueror, Don Jayne d'Aragon, ordered that the waters of a canal called the Cuart should be made to run into the sewers for two hours in every twenty-four, to carry off the filth. Near the walls of the town the inhabitants drew out the mud, and, after drying it in the sun, used it as manure, while those who lived further down dammed the stream, and forced the water to pass into ditches in their own fields. The result was that the portion of the Huerta de Valence which lay nearest to the canal became a perfect marvel of fruitfulness, and remains so to the present day. In Milan, in the middle ages, the sewage of the town, and the refuse of the woolen works, were received in open sewers, which surrounded the town, and the contents were carried to the river Po by means of an old bed called the Vettabia, which traversed the lands of the Abbey of Clairvaux, belonging to the monks of Citeau. Tradition says that it was Saint Bernard himself who conceived the idea of feeding the abbey lands with the foul waters of this stream, and that the result of his experiment was marvellous. In the fifteenth century Francois Sfforza cut the canal of the Mortesana, and appropriated the water of the Adda for the cleaning of the sewers of Milan. The irrigation was then extended over between three and four thousand acres; and this, with the great industry of the people of Lombardy, created the *marcites*—meadows which yielded in some cases as many as eight crops in the year, supported more than three milch cows on every hectare (two-and-a-half acres), and gave rise to the famous manufacture of Parmesan cheese.

MODERN SYSTEMS.—In London and some other cities, the sewers were originally intended to carry off rain water only. Up to the year 1815 it was penal to discharge sewage or other offensive matter into the sewers; cess-pools were regarded as the proper receptacles for house drainage. But as the population increased, the subsoil became thickly studded with cess-pools, improved household appliances were introduced, overflow drains from the cess-pools to the sewers were constructed; thus the sewers became polluted, and covered brick channels were necessarily substituted for existing open streams. In the year 1847 the first act was

obtained, making it compulsory to drain houses into sewers. The present English solution of the problem, as developed in their general systems of town drainage, has been to construct underground, generally along the center lines of streets and alleys traversing the districts to be relieved, conduits of masonry; or to lay stone-ware pipes. Into these all house and factory refuse, and all cast-off matter which can be floated, are conducted by means of branch drains and street gulleys, and by the aid of an ample public water supply and occasional rainfalls, through these conduits into natural watercourses, to be diluted so far as to be inoffensive. This manner of disposing of city sewage is called the *water-carriage* system. It is, with some exceptions, the general practice in England; and, so far as sewage works have been designed and constructed in the United States, the universal practice.

In cases where there is insufficient fall from the street sewers to the place of deposit, pumping is largely resorted to; the whole of the vast low level drainage of London, amounting to more than 83 square miles, is thus disposed of. The cities of Liverpool, of Leamington, the proposed immense drainage of Glasgow, besides numerous great cities on the continent, like Berlin and Hamburgh, have works conceived and executed with the same view. Similar works are proposed for some of the American cities; Troy among others.

The mixing of fecal matter with water, and disposing of it through the sewers, finds, however, little favor on the continent of Europe, and is obliged to encounter much opposition from some of the ablest scientists and engineers in England. It is condemned on account of polluting the natural watercourses and depriving agriculture of a valuable fertilizer. The tides of the ocean, even, are proved inadequate to remove the sewage cast into it. The expectations respecting the transporting action of the tide have proved completety delusive, as the blackened foreshores of Erith and Greenhithe, and other places on the Thames, can testify. Any town that discharges its sewage into the sea, or gets rid of it, as the usual term is, by this method, will find that there is a vast difference between a simple transference and a complete removal. Absorption, not solution nor dilution, is the only manner in which to effect the complete removal of sewage, and that is a faculty enjoyed in the fullest degree only by the soil and the wonderful assimilating action of plants. To avoid the nuisance and the waste of throwing the sewage into streams or the sea, the fertilizing matter must either be kept out of the sewers altogether, and a different system of collecting and transporting it devised, or else it must be collected at the outflow point of the system. It may in either case be deodorized, should that process prove successful The main drainage of London is intended to float or propel by running water, all the sewage of the town, to a point far below the town, where the fertilizing matter will be collected in solid form. The Paris system is the same, and has been frequently described. During the last twenty years, a complete system of drainage, terminati g in a main sewer with a flow of from three feet to six feet per second has been attained, and the authorities have finally determined that the Seine should be cleared of the pollutions of the town. In Paris, however, the use of cess-pools continues to a great extent, and the foul matter of the houses is not in all cases passed into the sewers. But the cesspools are properly cared for and cleaned. But this is an expensive process. Over 2,000 tons per night are removed from private houses. Steam pumps convey over 500,000 tons per year to the basins at Bondy, six miles from Paris, and 50,000 tons of half-solid matter which the pumps will not act upon, is removed in casks. At Bondy the night-soil is transformed into sulphate of ammonia, and into *poudrette*, which is the solid deposit left in the basins, dried and sifted. But this method of preparation is very rude, and nineteen-twentieths of the useful matter are said to be lost.

In many American towns, however, the only system that can be *afforded* at present, is simply to get the sewage out of the town, by the comparatively inexpensive method of water carriage in the sewers. In the Memphis region, for instance, where this subject has come up for settlement, the land for agricultural purposes is too cheap, abundant, and tertile, and the scope of agriculture too limited to permit the expensive application of fecal matter as manure; and the further pollution of the Mississippi by the addition of the sewage from another city is a contingency altogether too remote for serious consideration.

REQUIREMENTS AND CAPACITY OF SEWAGE WORKS.—To what extent any system of drainage should be a modification or a suspersedure of the natural drainage, depends

on the topography, area, natural streams of running water, rainfall, and population which obtain in different districts or cities. The best existing systems of artificial drainage give evidence of having arrived at whatever degree of perfection they now possess by passing successively through the stages of improvement, and at least partial supersedure of the originally existing natural drainage. In some of the most densely populated cities the only traces of a former natural drainage are the lines of the main outfalls, which, to a greater or less degree, coincide with the natural lines of rain-water outfalls. Therefore, it is evident that the tendency of all systems of artificial drainage is inevitably in the direction of the *total supersedure of the natural drainage*.

The first question to be solved is the size of the sewers; to determine which, three elements are indispensable; the areas to be drained, the inclination of the sewers, and the maximum quantity of sewage and rain-water discharged in a given time from said areas. The first two of these elements only are known; the latter remains to be determined, and is composed, in cities enjoying a public water supply, in connection with a general use of modern house conveniences, of the *refuse water* holding the solid matter in suspension, and the *rainfall discharge*. The refuse water is found, in densely populated cities, to vary but inappreciably from the water supply in bulk; one-half of which, according to observations on the London sewers, finds its way to the sewers in six hours, and the other half in the eighteen remaining hours out of the twenty-four. Then, taking the water supply at 60 gallons or 8.0214 cubic feet per 24 hours *per capita*, and the resulting sewage as the same in bulk, one-half of which being discharged in six hours, and rating the ultimate population at seventy-eight persons to the acre, equivalent to fifty thousand per square mile, there will result 0.0144 cubic feet as the sewage per acre per second (equivalent to a rainfall 0.0143 in. in depth per hour), rated according to population and water supply. The rainfall discharge depends upon the depth of rain falling in a given time, and the condition of the surface upon which it falls, whether dry, wet, frozen, paved, built over, or cultivated; modified by the declivity of the slopes along which the discharge takes place. Mr. Bazalgette's paper on the London Main Drainage, says: From careful observations of the quantity of rain falling on the metropolis, within short periods of time, it has been ascertained that there are about 155 days per annum upon which rain falls; of these there are only about 25 upon which the quantity amounts to $\frac{1}{4}$ of an inch in depth in 24 hours, or the 0.01 part of an inch per hour if spread over an entire day. Of such rain-falls a large portion is evaporated or absorbed, and either does not pass through the sewers, or does not reach them until long after the rain has ceased. In the report of Messrs. Bidder, Hawksley and Bazalgette, in 1858, on the subject, it is stated that continuous observations, show that the quantity of rain which flowed off by the sewers was, in all, cases, much less than the quantity which fell on the ground; and although the variations of atmospheric phenomena are far too great to allow any philosophical proportions to be established between the rainfall and the sewer-flow, yet they feel warranted in concluding, as a rule of averages, that $\frac{1}{4}$ of an inch of rainfall will not contribute more than $\frac{1}{8}$ of an inch to the sewers, nor a fall of 0.4 of an inch more than $\frac{1}{4}$ of an inch. Indeed, they have observed rainfalls of very sensible amounts failing to contribute any distinguish able quantity to the sewers. But there are in almost every year exceptional cases of heavy and violent rain-storms, and these have measured one inch and sometimes even two inches in an hour.

As to the size of sewers, in Great Britain and on the continent, experience has demonstrated that improper substances admitted into sewers will obstruct them, no matter what may be their dimensions, and must be removed by manual labor. To effectually meet this evil, the earlier practice was to make all the sewers large enough to conveniently admit men, to pass through them and remove matter which should never have found its way into them. Sewers constructed upon this plan are costly to build and keep clean; they induce the admission of refuse which cannot be removed by water, but which could generally be carted away much more economically from the surface at the points of accumulation than by being first unwisely forced into sewers, thence exhumed by the tedious and life-destructive labor of the sewer-scavenger, and then carted away; calling into requisition a "description of labor which it is improper for human beings to perform, and which ought to be forbidden, as being false in principle, and belonging to a low state of art, and as being ignorant or interested excuses for the avoidance of the trouble and expense

of practicable and efficient substitutes." As sanitary measures, large sewers are very objectionable. The constant accumulation of foul matter during the dry season of each year, when the flow of sewage does not keep the main sewers clean, would convert them into elongated cess-pools, and thus originate or aid in prolonging epidemics to a fearful extent. To keep sewers of this magnitude clean, by flushing them with water from the public water supply, would involve an expense for elevating water for this purpose alone, which at present cannot be estimated; except in very flat districts, it appears preferable to provide for the removal of excessive rainfalls, by natural drainage, or by surface drainage, and to provide only for the ordinary quantity in the underground system. The main sewers of the Memphis works are designed, when running full, to discharge three times the maximum quantity of sewage independent of rain-water, or three times 0.0144 cubic feet per acre per second, as heretofore determined; *i. e.*, the sewers are made sufficiently large to carry into the river sewage equal in volume to a discharge of one inch of rain in 24 hours. The minimum inclination of the main sewers is to be 3.168 feet per mile, which, in the case of a three-feet sewer, when running half full, will produce a velocity of current equal to 2.6 feet per second, or 1.4 miles per hour, calculated by Prony's formula. The actual velocity, however, in a sewer of this size and inclination, when half filled, is greater from the fact that at every junction with its branches (provided the junctions are properly made) the volume of sewage flowing in the main sewer receives an increment of velocity arising from the greater inclination of the branch sewers.

In all main sewers, however, there will be accumulations of solid matter, and to provide for its decent and economical removal, catch basins are, in the best practice, built under the line of the curb-stones, at the street corners where the surface water from the gutters flows into the sewers. They have trapped connections with the sewers, and movable cast iron covers. At the junctions of the catch-basin discharges with the branch sewers, and at all changes in the alignments of sewers there are also man-holes, located in the center of the streets, and fitted with perforated covers, to facilitate inspection and the removal of deposits, also to ventilate the sewers. It is also well to place intermediate manholes, every 100 feet, to determine the location of deposits. These may be covered by the pavement, to save cost, as they need not often be uncovered.

VENTILATION OF SEWERS.—Gas evolved by decomposing organic matter in sewers, is always dangerous to health. In small quantities it poisons the blood and produces typhoid and those other diseases commonly termed *zymotic*. In a perfectly undiluted state the gas would cause instant death. In his evidence before the Select Committee on the Sewage of Towns, Dr. R. A. Smith states that sewage is oxidised even before it leaves the town, and that poisonous gases, are evolved in large quantities. Whenever the temperature rises to about 54°, which is the usual temperature of sewers, oxidation is intensely rapid. The gases are generally as follows:

Carbonic acid	95.0
Nitrogen	2.6
Sulphuretted hydrogen	2.0
Carbonic oxide, hydrogen, and carburetted hydrogen	0.4
	100.0

The motion of the liquids constantly exposes fresh matter to the influence of the air, and the solid matter deposited in the sewers or adhering to the sides, being in an advanced state of decomposition, the exhalations are of the most deadly character.

What becomes of these gases? It has been supposed by some that the carbonic acid gas being heavier than air, finds its way to the outfall and is dissipated in the air; this is clearly an error; the law of gaseous diffusion militates against this theory. The constantly accumulating gas is soon rendered highly concentrated by the temperature in the sewers, and as soon as the pressure of this exceeds the hydrostatic pressure of the water in the traps it escapes. The bubbling noise not uncommonly heard in closets and sink traps is caused by gas escaping in this way; moreover, sewer gases are extremely soluble; water readily absorbs more than its own volume of carbonic acid gas, consequently the water in the traps rapidly become highly charged with sewer emanations, which cause it to putrefy and evolve most dangerous gases into the apartment.

The ventilation of sewers by grates opening into the streets—the delivery of these gases into the very midst of the street throngs and into the doors and windows of houses, is hardly a remedy of the evil. To disinfect sewer gases before they can reach the street, vegetable charcoal spread lightly on a perforated tray or basket has been fixed in con-

nection with the man-holes. When dry it effectually purifies the gases, but as it absorbs water rapidly it requires to be renewed frequently. The steam and damp vapors from the sewers will in short time render it useless. Elaborate and expensive ventilating chambers have been erected on this plan in West Ham and some other places. The process is theoretically correct, but its practical value is very doubtful, for the reasons stated. It has been proposed to connect the sewers with factory or other chimneys, so that the gases may be discharged into the air at a great elevation. There is reason to believe that this method may be made successful. The expense of building special chimneys and keeping up a furnace would be too great to be entertained, unless all other reasonable schemes result in failure; but if a factory chimney exists near the summit of a sewer, a connection can be made with very little expense. A small central chimney would be useful only for a short range; the air would be drawn with great force into the sewer, through the traps in the neighborhood; while the sewers at a distance would not be affected in the slightest degree. Rain-water spouts have been used in some instances; but the objections to this system are numerous. During heavy storms, when the sewers are being rapidly filled with water and when some outlet is specially required, the spouts are required for their legitimate function; besides which, leaves and birds' nests cause frequent obstruction. The gases would, moreover, be discharged into the immediate neighborhood of bedroom-windows.

The corporation of Liverpool has recently incurred great expense in the endeavor to solve this important problem. Over 1,000 iron shafts, about eight in. in diameter, with revolving tops, have been fixed in corners or recesses. These shafts are joined to the sewers in convenient places, and are also carried far above any windows. A great reduction in the rate of mortality has followed their adoption.

APPLICATION OF SEWAGE TO AGRICULTURE.—The following are recent facts regarding the experiments on the application of sewage to agriculture, at Paris. Two methods, which may be called the agricultural and the chemical, were to be tried simultaneously. A laboratory was also fitted up for the daily analysis of the sewage water. Near the mouth of the great sewer at Asnières, a centrifugal pump capable of raising 500 tons of liquid per day, was erected and a plot of ground, about four acres in extent, was laid out. The sewage water, merely passes along the small channels which bound the beds, in which various kinds of plants are cultivated, but especially roots; the water filters through the soil, feeds the plants and leaves in the channels a valuable deposit, which is incorporated with the soil and which applied to bare land in winter produces the same effect as good manure, and prepares the soil for spring crops. No other kind of manure is ever used at the Clichy establishment. The products are of excellent quality. From November, 1867, to July, 1868, 26,000 tons of sewage water have been applied to the soil there; the water is therefore purified naturally, and at the same time acquires a commercial value which is estimated at about one halfpenny per ton.

The report of Messrs. Bateman and Bazalgette on the sewage of Glasgow says: The application of sewage to land has not only resulted in an amazing increase of its productiveness, but, where the application is properly conducted and the ground suitable in character, the sewage is deprived of all objectionable smell and appearance, and may then be safely permitted to flow into such a river as the Clyde or into the sea on any part of the coast. Probably the most notable instance of the successful agricultural application of the sewage in this way, is over the Craigentinny meadows near Edinburgh, where the land has been made to produce 40, 50 and 60 tons of grass per acre, per annum, which is generally sold to persons, who cart and carry it away themselves, for prices generally exceeding £30 per acre, and in some instances upwards of £40. There, however, the mode of application has been defective—the ground has been overdosed with sewage, and its objectionable qualities have not, therefore, in a sanitary point of view, been wholly removed. At Croydon, the purification of the sewage of that town, by passing over grass lands in the immediate neighborhood, has been so successful that people residing close up to the sewage-irrigated land do not complain of any nuisance; and so entirely devoid of color, smell, or taste is the sewage, after having passed over the ground, that on comparing a bottle of it with a bottle of water from Loch Katrine, without knowing in which bottle the respective waters were contained, one of us actually selected the Croydon sewage water as being that which he believed was Lock Katrine water. Similar results

have attended its application at Rugby, Carlisle, Barking, and other places; and there can therefore be no doubt whatever that foul sewage, after being properly and sufficiently passed over suitable land, and applied to suitable crops, may be wholly deprived of its offensive character. The land which it appears is best adapted for effecting this purification, is well drained friable clay or sandy loam, free enough to absorb the sewage and gradually allow it to filter through, but not so free or open as to allow it to pass through too quickly. Sands and gravels, too, appear to produce this disinfecting result, and all crops are apparently suited for the reception of sewage, though that to which it can be most readily applied, and which, perhaps, in its turn produces the most beneficial result in its purification of the sewage, is grass land, especially rye grass, cut green and carted from the ground.

The application of sewage to agriculture has met with two serious drawbacks in England. At first the local authorities and the farmers were at open war, and everything was carried on under compulsion. No sooner did the local boards discontinue the pollution of the natural water-courses, and apply the fecal contamination to the land, than it became necessary to endow them with power for the compulsory purchase of land needed, as no farmer would willingly permit them to use his fields for the purpose. As the prejudiced mind of the agriculturist became more enlightened by the undoubted success and value of sewage irrigation, it began to entertain another grave error, viz: that the only difference between the present and future methods of manuring land consists in the substitution of one fertilizer for another. This is a serious mistake. The one is a simple and primitive mode, capable of design and execution by any common farm laborers; the other is an accurately and carefully planned project, requiring, from first to last, a high degree of professional skill, and technical knowledge and ability. Thus it is that in the few instances where the agriculturist has been his own engineer, his attempted utilization of sewage has eventuated a miserable failure, greatly to his own surprise and chagrin, and also to the detriment of the principle which he tried to put into execution. Regarding sewage irrigation as applicable to every description of crop, it must, in every instance, necessitate some preliminary preparation, or surface formation of the land, which it is intended to irrigate. This circumstance mainly contributed to the restriction of sewage irrigation principally to grass crops, which admit of a very reckless and unscientific distribution of the fertilizing fluid. The case is otherwise where cereal crops are concerned. According to the physical contour of the land, so will the preparation of its surface be more or less expensive. As the ground must be prepared for a railway before the permanent way can be laid, so is a similar operation, in a minor degree necessary to insure the proper and remunerative disposal of sewage.

ARTIFICIAL PURIFICATION OF SEWAGE.—Various schemes for this purpose have been tried and many others are on trial and proposed. The Paris experiments before referred to, are as follows: A solution of sulphate of alumina is made in the proportions of two hundred weight of the alum to 1000 litres of water, and two litres of this solution were used for every ton of sewage to be purified. The price of the alum delivered at Clichy amounted to eleven francs per 100 kilos., about 4s. 6d. per hundredweight, making the expense of purifying a ton of sewage something less than one farthing. Lately a pure solution of the sulphate has been obtained; one pound is mixed with two or three times its own volume of water, for every ton of sewage to be purified. The solution costs about one shilling per hundredweight, and the expense of purification thus only amounts to one centime, or less than the tenth of a penny. The mode of carrying on the operation of clarification is very simple; the sewage water, after having received its dose of solution, is admitted into the basins, which it traverses slowly, while the particles in suspension are deposited as in the operation of fining; the water flowing out of the basin is so pure that it may be turned into the river. The basins are emptied about once in six weeks, and their deposit is removed without difficulty. The clarification occupies less than ten hours; the water, black on entering, becomes of a greenish tinge as soon as the solution of alum has mixed with it, and passes off at the further end of the basin pure. The manure left at the bottom dries readily when the layer is not much more than four inches thick. It passes from black to brown, cracks, and assumes much the look of cork. Very little smell is given off either from the basins or the irrigating gutters; the gaseous matters are almost immediately consumed

by the air and light. The precipitated matter contains from fourteen pounds to sixteen pounds of nitrogen per ton. More than 50,000 tons sewage water have been clarified in twelve months, producing about 100 tons of precipitate. The composition and nature of this precipitate place it exactly on a footing in all respects with the refuse of mud swept from the public streets. Side by side with the practical experiments, careful scientific examinations are pursued in the laboratory. As already stated, a ton of the sewage water contains about six pounds of various foreign matters; azote, phosphoric acid, alkalies, organic and earthy matters. The precipitate contains half the azote, all the phosphoric acid, and most of the organic and earthy matters, while the clarified water holds in solution the other half of the azote, and all the alkaline matters. From these data the values of sewage water are ascertained to be as follows: A penny a ton for the fluid as it exists in the sewer collector, and the precipitate about eighteen shillings per ton; the total quantity poured into the Seine daily averages 200 tons, so that the value of the sewage water would amount to about £300,000 per annum.

The A. B. C. process of Mr. Sillar about which so much is said in the English papers, is named from the initials of its three principal ingredients, animal charcoal, blood, and clay. When this compound is suspended in water and added to the sewage, a precipitate in large flakes is immediately produced; the supernatant liquor is drawn off into a tank and a small quantity of perchloride of iron solution added. The iron compound serves to remove the sulphuretted hydrogen. It has been found convenient to add a certain proportion of alum, since the process is thereby accelerated. This process was tried at Leicester, where the lime process had previously been used. Dr. Frankland's report upon it says: The purification of sewage may be conveniently considered under two heads—1st, clarification, or the removal of suspended matters, so as to make the resulting liquid more or less clear and transparent; and 2d, removal of matters in solution. The suspended matters contained in sewage are well known to undergo rapid putrefaction and to become very offensive; consequently their removal either by filtration or chemical treatment constitutes in itself an important amelioration in sewage. But the liquid so clarified contains in solution much nitrogeneous organic matter, which is prone to become putrid even when mixed with a considerable volume of river water.

In conclusion, the results of the experiments may be thus summarized:

"1. The Sillar and lime processes remove to a great and nearly equal extent the suspended matters contained in sewage.

"2. Sillar's process increases the amount of dissolved solid impurity in sewage, but reduces the quantity of putrescible organic matter. The lime process reduces both the amount of dissolved solid impurity and the quantity of putrescible organic matter; the reduction of the last being about the same as that effected by Sillar's process, viz: rather more than one-half.

"3. To the manufacturer of solid manure from sewage, Sillar's process is greatly superior to the method of treatment by lime, although it fails to extract from the liquid more than a very small fraction of its valuable constituents."

ADVANTAGES OF IRRIGATION OVER DEODORIZATION.—The report of Dr. Frankland further concludes: "Like all chemical methods hitherto invented, both processes fail in purifying sewage to such an extent as to render it admissible into running water. It still remains a fact that no chemical process is known which even remotely approaches irrigation in its efficiency as a purifier of sewage."

The report of Messrs. Bateman and Bazalgette, before quoted, says: "All attempts at deodorization or precipitation on a large scale have hitherto so completely failed, either commercially or chemically, that, in our opinion, the idea of correcting the evil by any such process need not be regarded; and hence it becomes necessary, either to turn the sewage in its natural condition into the sea at some point sufficiently distant from populous places or districts, or, by allowing it to pass over a sufficient area of suitable lands to clear it of all objectional character, and to render it so pure that it may without fear of creating a nuisance be turned into the river or the sea." The "Engineer" in discussing this subject, concludes that every discription of disinfecting and deodorizing nostrum has been allowed a fair trial, and the practical result has been, without exception, a complete failure. They all come to grief in one of two ways, and generally in both. They all have failed to convert the solid or semi-solid residue into a marketable manure, which will sell, speaking

broadly, for anything. A few of them have been successful in purifying the sewage so far that the liquid might be run into a stream, where the owners were not over particular. This is nothing more than a feat that any decently educated chemist could accomplish. The only real and efficient purifier of sewage is the soil, and no chemical process has been yet discovered which will effect this object and at the same time retain or fix the valuable fertilizing ingredients. From the recent report of the results obtained at Barking Farm, it will be perceived that there is no longer any doubt upon the subject. In spite of the poverty of the soil at Barking, the sewage has been able to confer upon it all the fecundity belonging to the richest lands. Splendid cereal crops, fields of bulbs and roots, have resulted from the application and the thoroughly efficient manner in which the farming operations are conducted.

THE SUEZ CANAL.

PRESENT STATE — PARTICULARS — USEFULNESS—ENGLISH OPINIONS.

In a communication to Paris, M. de Lesseps states that a small schooner, "La Levrette," has recently passed through the Suez Canal, and that six vessels belonging to the Egyptian fleet are about to pass from one sea to the other. It now may be safely said that this canal is opened for vessels of small tonnage; and in six months' time ships of from 2,000 to 3,000 tons burden will be able to make use of it.

The Suez Canal is about 90 miles long, and will be 328 feet wide at the water line, 74 feet at the bottom and 26 feet deep. The slopes under water are very flat—five to one. The excavation will have required the removal of 96,000,000 yards of earth. The work presents no engineering difficulty except magnitude. The cost is estimated at 60,000,000 to 75,000,000 dollars gold.

As to the usefulness of the canal, the Dutch Commission report that it will help sailing vessels bound beyond the Indian Ocean very little—ten or fifteen days in 100; but that it will save steamers fifteen to seventeen days in a voyage of 60 to 70 days. The rate of toll is not decided, and it is stated that steamers will not be allowed to use their own propellers, but will be towed by some means that will not wash the banks. The English papers are "calculating" that it will hardly pay.

An American scientific writer, sojourning in London, ten years ago, prepared an elaborate article favorable to the Suez Canal. The article was thrown out by the proprietor of the journal to which it was contributed. But, said the writer. "the project must succeed—there are no insurmountable difficulties." To which the proprietor replied to this effect, and his reply sums up the British opinion of the period: "The Suez Canal is not recognized as a proper subject for professional discussion in England. Englishmen have determined that it should not succeed." But British opinion is subject to change on this as on other subjects, and the "Practical Mechanic's Journal" now makes this handsome acknowledgement.

The Suez Canal—after years of labor and perseverance againt every obstacle and discouragement, enough alone to immortalize the names of Lesseps and those who have, like his able contractors Lavalle and Borell, stood staunchly by him through every difficulty—at last begins to prove itself to the world at large, and even to the most incredulous eye, as about at an early period to be accomplished. In fact, in some sense, it is so already. The Sweet Water Canal has already conferred great agricultural benefits upon the country through which it passes, and must prove hereafter a source of uncountable riches to Egypt, and of great revenue to the canal company. The English engineer who showed himself, as regards this Suez Canal question, the only competent one —for Mr. John Hawkshaw, in his able report, boldly stated that it was not only practicable but easy to construct, and that the dogmata of Robert Stephenson as to the impossibility of keeping it open were purely chimerical—has stated, that he would undertake to irrigate the whole land of Egypt, *i. e.*, all its tillable land, from that canal.

A condition produced by the relations of the salt water or great ship canal and the arid climate of Egypt, which Stephenson never thought of, has since been carefully taken into account, and it is now certain that whenever the sea shall be let into and fill the Bitter Lakes, the evaporation from the water surface alone will be such as to cause a considerable current through the canal, which, according to Stephenson, would be "no more than a stagnant ditch;" indeed, the question has been raised whether the scour due to this cause and to alternate ac-

tion of the tides, though these are small at either end, may not prove more than desirable. The effect, however, of this evaporation will unquestionably be to totally and rapidly change the whole climate of Egypt, so that, irrespective of any irrigation, it will probably become sufficiently moist to gradually put an end to the Egyptian Sahara, through the unseen working of the forces of nature. Should this even in a minor degree be realized, and there can be little doubt upon the subject, it will be probably the most wonderful result in the modifying of cosmical forces as found in nature ever achieved by human means.

England has all along occupied a most unenviable and unfortunate position as regards this grand project, of which France may be so justly proud, and the completion of which we hope the Emperor may live to see, and to know that it will be one of the events by which history will mark his reign. But we will not go back upon the unpleasant track of misjudged policy, mainly due to Lord Palmerston's political prejudices as to Eastern affairs, sustained by R. Stephenson's engineering misjudgment, in which the facts and deductions were fitted for the political foregone conclusion, rather than to nature and reality. The recent tardy sort of half retraction of ancient opposition and prejudice on the part of the *Times*, and some other English leaders of opinion, is but a pitiful display of grudgingly admitted error and half-given praise. The old story, "it will never pay," however, is still raised, but no attempt is made upon any solid and sensible basis of figures, in Great Britain at least, to prove that that is so.

RAILWAY ACCIDENTS.

HASTY CONSTRUCTION—IMPERFECT EARTHWORKS.

The "Railway News" divides railway accidents into two classes; those arising from moral causes, such as disobedience of orders, and those arising from physical causes, such as mal-construction. Particular reference is made to the settling of embankments. A few inches above section line are generally allowed, but it is never enough; embankments have been known to shrink a foot to the yard—that is to say, an embankment of thirty feet high, left full height, has been known, after excessive rain, to sink ten feet and some even more than this—sand-banks not so much. Here, then, is the primary cause of numerous railway accidents. The construction of railways is always hurried forward; cuttings and embankments are often begun and finished before any wet has been on them; they are prettily carried out and completed according to the plans and sections, the sides are nicely soiled and sown, and the young engineer, having his exact depth of cutting, exact height of embankment, and exact two feet of ballast, all according to specification, is satisfied. In nine times out of ten the practical navvy knows this is wrong; but it matters not to him. He must obey the engineer, and he gets paid; and in the contingency mentioned he may possibly get paid a second time for the same work. Banks should be—and are supposed to be—constructed of half round form, the centre six inches higher at least than the sides, in order that, when the water makes its way through the ballast, it may meet this convex formation, and so be sent both sides out over the embankments—good in principle and effectually preserving banks in good order when thoroughly carried out; for it is not the quality of rain that falls that spoils banks and renders them dangerous, but the quantity that finds its way into their centers. But on the contrary, when the rain comes the banks go. The ballast is now on; they cannot be opened out and remade, because of the traffic and for other reasons; so more ballast is heaped on, as many feet of it in many instances as there should be inches, the consequence being that the symmetry of the bank is lost, the rotundity between ballast and formation is gone, the water settles into the embankment, and ballast for the future does more harm than good, the water finding its way out by means of slips and other channels that strain the permanent way. The sleepers may be sound, the rails good, and the fastenings of the most approved kind; but if this strain, unprovided for in office books, comes on, away goes the road, and under some extra speed or weight, or during the 48 hours between Saturday and Monday that the platelayer's watchful eye is off his beat, the fastenings are unfairly tried, the guage is forced out, and off goes the train.

This was, no doubt, the case at Tuxford, on the Great Northern, some five or six years ago. About two years ago it was the cause of that terrible accident on a heavy bank on the Chatham and Dover, and more recently, on the branch line between Leam-

ington and Rugby, this was evidently the real cause of the accident. Of course accidents occur on banks and in cuttings too from other causes, and it is not denied that sharp curves and steep gradients do their part; but the above is chiefly the cause of the class of accidents we are now discussing, and they are only to be avoided by the non-ballasting of embankments until they have had two or three seasons on them, and have had time to become permanently consolidated. If lines must be opened before that occurs, less risk a thousand times to run (at reduced speed, if you like) over banks without any ballast at all. By good management and constant packing, the road can be maintained almost as well without, as with ballast; indeed, very much better than on banks where the super-quantity of ballast acts only as a perfect trap to catch and hold all the rain that falls; and then, after two or three winters have been on the banks, the road may be finally lifted, set, and ballasted, and it will never cause either trouble, uneasiness or accident.

PROGRESS OF ELECTRO-METALLURGY.

COATING SHIPS' BOTTOMS—SILVER PLATING, ETC.

From the "Mechanics' Magazine."

In the year that is just ended, but little has been added to our knowledge of the laws of the electro-deposition of metals, and not a great deal to the application of laws already known; still, some progress has been made, in the modes of carrying out these arts. Last year we noticed a new application of electro-coppering, as applied to the coating of ships for the prevention of fouling and corrosion, which had then but newly been tried, and we were then in hopes that by its means copper would soon be successfully applied to the bottoms of ships for their protection, but yet little progress has been made in that direction. Not that a firmly-adhering coating of copper cannot be applied to iron; we have seen this done repeatedly, but the difficulty is in applying it to ships. It can be done to ships' plates before being built into the ship; but the rivets must be coppered also—yet, if coppered, how are they to be riveted? Even if copper rivets were admissible on the score of cost and strength, they could not be on the score of electric action. For if they contained lead, as almost all commerical copper does, they would become electro-negative to the electro-plastic copper, and so assist to destroy the coating of the plates. It is true that electro-plastic copper could be made into rivets, but this would be at double the cost at least, and this would enhance the price enormously, the rivets required being both very large and numerous. But besides these considerations, copper rivets would not be strong enough. Are we, then, to give up all hope of coating iron ships with copper? By no means; but it will not be by the direct application of the copper to the iron. We think the difficulties of such a process are too great to be successfully overcome. The process which appears to us most likely to succeed, is to coat the plates of iron with copper by electrolysis (the iron giving strength), and with these plates to sheath the bottom of the ship, between the the sheathing and the ship an insulating substance being interposed. Of course, in this way, a ship could be sheathed with ordinary commercial copper, but the sheets would have to be of sufficient thickness to prevent buckling and bulging from the insulating material, so that with plates wholly of copper the sheathing would be six or eight times the cost of that we have hinted at. We should like to see thin iron plates coated with copper, applied as sheathing on a large scale. We have seen it tried on a small one, and have but little doubt of its success on the large.

In electro-coating with silver, as applied to copper, brass and German silver, there is nothing new; except with regard to the coating of the alloy of lead and tin (common soft solder) with silver. This practice has become much more extended, and is a deception and a cheat. The forks and spoons are roughly made of a common kind of German silver, or, rather, a highly speltered brass, without a particle of nickel in it, and then coated with common solder by immersion in the melted metal; they are then easily rubbed down smooth, and the expense of filing, burnishing and polishing saved, and this is the reason why this practice has been resorted to. There certainly is more difficulty to the ordinary practitioner in coating this alloy with silver than in coating German silver, brass or copper. The same method cannot be pursued with this alloy as with the above metals. Mercurial cyanide or nitrate is of no avail to prepare it for the silver; instead of this as a preparation, the spoons or forks are suspended in a boiling

solution of caustic potash or soda for a short time, and then transferred quickly to the silver cyanide solution, to which is attached a strong battery, so that they may be quickly coated with silver, and the action of the cyanide solution on the alloy is prevented by rendering it strongly negative. When they are coated they look as well as other spoons and forks, but they soon chip, owing to the softness of the alloy under the silver, as well as the imperfect adhesion of the silver to the alloy.

There is another branch of electro-coating, wherein some progress has been made during the past year, that is the coating of iron, steel, and cast iron with copper and silver. To make silver to adhere firmly to iron and steel has been a desideratum much sought after for many years; indeed, ever since electro-plating was discovered. It has always been found much less difficult to make copper adhere to iron than to make silver adhere to it; consequently, it has hitherto been the practice to coat common dessert knives and nut-cracks with a thin coat of copper and then with a coating of silver. But these are much inferior to the solder-plated knives, called close plated, which is a thin sheet of silver soldered on to the blade with common solder. These are called the best plated knives, though plated with soft solder, because hard or silver solder is not applicable to plating knife blades, on account of the heat necessary, but to carriage, harness and coach fittings, hard solder plating is applicable, but its expense prevents it being much used. This new process referred to above is equal to hard solder plating, but cheaper than soft solder plating. The inventor of it calls it pyro-plating, because the fixing of the silver is done by heat, as also the preparation of the articles for silvering. Some four years ago, a patent taken by Mr. J. Baynes Thompson describes a process for obtaining a pure surface, whereon to deposit the silver, viz: by depositing a film of iron on the article. But within the last six months the same gentleman has taken out another patent and abandoned the previous one. In this new process there is no intermediate coating of any other metal, the silver being deposited direct on the iron or steel. The surface of the iron is purified by nascent hydrogen, the hydrogen being produced by the electrolysis of hydrate of potash or soda; the inventor prefers hydrate of soda. With care, no other salt need be added to this solution, but in manufacture such care can hardly be expected; therefore, it is expedient to add a small quantity of one of the compound cyanides: those preferred are the nickelo or cobalti-cyanides of potass. The necessity for these salts is this: If care be not taken to regulate the current of electricity according to the strength of the solution and the number of articles in it, as well as the heat of the solution, sodium will be deposited on the articles as well as hydrogen, and if transferred to the silver solution with that on, the silver will not adhere. The compound cyanide prevents that.

When the article is coated with silver it is subjected to a heat of between 400 deg. and 500 deg. Fah., so as to fix the silver, and after that it will stand a red heat without injuring the coating. Knife blades and all cutting instruments are silvered at a pale straw temper, so that the burning in or fixing of the silver may bring them down just to a proper cutting temper. We understand that the inventor has been fitting up a manufactory for the production of silvered articles in iron and steel, and that it will very soon be brought into full operation. Beyond these, nothing further of note has been done in electro-metallurgy; and though the advance during the last year has not been very striking, still gradual progress has been made.

Sinking Masonry in Marine Mud.—Contracts will shortly be issued for the construction of a floating basin at Bordeaux. Preliminary surveys and trials have been made, the result of which is that the difficulties of construction turn out to be less formidable than was imagined; the works will have to be carried out on a bed of marine mud about twelve yards in depth, but which is easily traversed by blocks of masonry fourteen yards high and with a surface of about six yards. Three wells have been made by means of blocks formed at the level of the ground, and which descend by their own weight as fast as the soil is taken out from the well. This operation presents, it is said, no real difficulty when the mud is dense enough to prevent the water rising in the well, and if a stream should flow in, a pump capable of lifting about 300 gallons a minute would soon pump the well dry. Under the conditions above mentioned the masonry descends to the depth of thirteen yards, exclusive of a stratum of very pure sand, four feet or five feet thick, which lies beneath the mud. Masonry thus placed has the solidity of a rock.—*The Engineer.*

RESISTANCE AND TRANSMISSION OF MOTION.

By Prof. Henry Morton, Ph. D. From the Journal of the Franklin Institute.

There are a number of phenomena more or less directly connected with the effect of high velocity in overcoming resistances, which are commonly regarded as forming a class by themselves, and requiring a special hypothesis for their explanation, or if treated in the established method, calling for an exercise of faith in a train of reasoning not in itself quite unexceptionable, which is at the least a sort of discomfort to ordinary minds. As an illustration of the phenomena to which we allude, we may cite the oft-quoted experiment of shooting a tallow candle through a pine board, the piercing a slate with a pistol ball, without cracking it, &c.

In an able paper by John C. Trautwine, C. E., entitled "Remarks on Force, Motion, and Inertia," published in the "Journal of the Franklin Institute," Vol. XLIV., p. 197, some of these difficult questions are very fully expressed. We will quote, for want of space, but one of the illustrations used, although we would strongly recommend the article to all interested, as an accurate and entertaining discussion of a subject which has been inadequately treated by some even of the highest authorities. After various other and more elaborate illustrations, Mr. Trautwine says: "The ordinary coupling between a locomotive and a heavy train, would break, under the action of an engine capable of imparting to the train at one impulse, a velocity of forty miles an hour; yet it safely transmits the same amount of moving force when imparted by a succession of milder impulses," and further on, "it would seem, that *moving force will of itself* sever mediums through which we may attempt to *transmit* too much of it, to *unresisting matter*, as well as to resisting force."

We believe that the obscurity of this subject will be greatly relieved, if only a little thought is given to the nature of those molecular forces which are the most usual active agents in the resistance and the transmission of motion. It will then be seen that these are forces which differ in nothing but their range of action, and intensity, from gravity, or other like energies, and may be fairly compared with them in their mode of action.

There is however, another point, which, though self-evident, is apt to be overlooked in our study of all forces, and that is their relation to time, in the respect, that the effect of any force must be proportional to its time of action. Thus, if a force is capable of producing a certain effect in one instant, it will do the same twice over in two instants, and can do but half as much as this in half the time. We should then first regard the particles of bodies as maintained in their relative positions, not by any general and indefinite condition of contact, but by the constant action of certain forces of great but limited power, and exerting this power, not without reference to time, but on the contrary, with entire dependence upon it; so that each element is exerting so much force in so much time, more in more time, less in less time, in a direct proportion.

These general principles being premised, we will presently assume a case involving the transmission of motion, and test our theory in its explanation. Our conception of this subject will be rendered more easy, however, if we first consider a parallel case in which gravity might take the place of the transmitting or molecular force. Imagine the earth at rest in space, with a heavy body in contact with it at some point. If, now, the earth received a motion in a direction radial to the point of contact and away from it, the heavy body would remain in contact so long as this motion was not greater than that of a body falling from a state of rest, *i.e.* (sixteen feet in the first second, and so on), In other words, the attractive force between the heavy body and the earth (which here represents the molecular force of our actual experiment), is just equal to that which we express by so much matter (the weight of the heavy body), moved sixteen feet from a state of rest; this power being put forth in the time of one second. If, now, we required a greater force to be transmitted by this attraction of gravity; either by asking it to move a greater mass at the same rate (as by connecting the heavy body by a string, with another so placed as to be free from all resistances to motion), or by demanding a higher velocity (as by supposing the earth to move more than sixteen feet in the first second), we should simply rupture the connection between the earth and heavy body. By keeping within the limits of the *transmitting* force (which in the above case was gravity, but might be any other), we can

transfer, part by part, any amount of force to the second body, which will be converted into motion in it, and be so stored up and accumulated without loss, all resistances being removed.

We will now take up an actual case of transmission to which our principle should supply an explanation. A weight, W, rests without friction on a level plane, and a power, P (derived say from the action of gravity upon a heavy body), is caused to act upon it by means of a cord passing over a fixed pulley. In an instant of time, gravity exerts a certain pull upon the heavy body, which we may assume to be transmitted instantly to the first point of the cord; but how is it to travel along the cord? It is clear that the only mechanical connection between the successive points of the cord, is their *cohesive attraction for each other;* it is then by what we may be allowed to call a *stretching* of this attractive force, that the power, P, can be transferred along the cord to W, and by no other means. Now, this molecular force is, as we have already seen, properly expressed by, and in fact constituted of, so much power in so much time. If, then, we draw one of these atoms from another with a force which is greater in the *same time* than that uniting them, a rupture will occur, and so much force only be transmitted as was exerted by the molecular power during the time that the weight was acting upon it.

The questions and conditions here noticed, lead us to another cognate subject of similar difficulty, and amenable to similar treatment; we allude to the relations between the moving force and the work done by a moving body. We say and know that the *vis viva* or work done by a moving body, varies with the square of its velocity, while we know, by our previous reasoning, that the force expended in giving it that velocity, only varies with the velocity itself. Thus the force of gravity will give a falling body a double velocity in a double time, during which it must have exerted a double force upon it. Here, then, we have a double force, doing a quadruple work. Is this because, by some wonderful and recondite property inherent in "velocity," the double power has been indued with an again doubled efficiency? Many writers leave us to think so; but we, on the contrary, believe that the work done *only seems to increase* more rapidly than the power implied in the increased velocity, by reason of a *loss of efficiency* in the resistances, in the overcoming of which the "work" consists, and in fact, that work in this sense, is no true measure of force.

As we have before seen, the molecular forces (which are those that most commonly play the part of resistances) as well as all others, exert powers proportional to the times of their action. If, then, a moving body with a certain velocity, overcomes a certain number of these resistances, or, for example, penetrates a medium to a certain depth, before its motion is arrested, it has overcome so many resistances, each acting for such a length of time. If, now, the same body with a double velocity, meets the same medium, it will penetrate each resisting element in half the time, and so receive from it but half the resistance it experienced before. If, then, its total force were *only equal* to what it was at first, it would go twice as far, or overcome twice as many resistances; because each of them would be but half as effective as at first. But as we know the double velocity implies a double total force, and thus, considering the doubling of the force and the halving of the resistances, we see why the number of these overcome, or the work done, should be fourfold. Similar reasoning would apply to the case of a body resisted in its upward motion by the force of gravity. A double velocity would give a four-fold height to its upward path, because, traversing each distance in half the time, gravity would exert but half its former effect within the same space, and so on, as before followed out. The body would come to rest when exposed *for a double time* to the resisting force of gravity.

It may be objected that the time of action is not the true measure of a force, but rather the distance which it causes a body to move in a given time. But that this is not so, will be seen when we consider that any velocity once implanted in a body, needs no force to maintain it, so that all the motion afterwards executed by reason of that element, is a clear gain having no equivalent of expended force as its representative. Thus, a falling body acquires during the first second, a final velocity of thirty-two feet per second. If gravity then ceased to exist, it would still travel this distance in the next second, while if the force still exist, and is to be expressed by the motion produced, we would have it responsible in the first second for sixteen

feet, and in the next for forty-eight. It is precisely this which introduces the philosophical error into the method of estimating force by the product of mass, into the square of the velocity.

But again, it may be said, the true measure of a force is the heat it develops, and this, as we know, varies with the square of the velocity. We would reply that all development of heat is unquestionably of the nature of overcome resistances. Thus the vibratory motions given to the atoms of bodies, are given in opposition to and by overcoming their molecular forces, and therefore, as in other cases, these forces will each individually oppose a *shorter* resistance to a body with high velocity, and thus render a greater number of their companions necessary to counteract its motion. In other words, the previous explanation may be applied word for word to this case. Or, we may say, the change produced in the individual atoms of a resisting medium, which we have heretofore called overcoming of their resistances, *is* heat. Therefore, if a double velocity overcomes a four-fold number of resistances, it develops a four-fold amount of heat.

In conclusion, we would again remark that the foregoing discussion is in nowise intended as suggesting a new system of mechanics. The rules at present employed are perfectly correct in their working, and more convenient in form, we think, than any which could be established on another basis. Like many rules and methods in mathematics, they are without reference to the rationale of the process, but accurately fitted to its requirements. Thus, for example, to take a simple case in arithmetic, in place of dividing one fraction by another, we invert the second and multiply. This is perfectly correct and unobjectionable as a method of obtaining certain results, but if the final expression (e. g. $\frac{1}{2} \times \frac{3}{1}$) were regarded as a rational explanation of some process (the inverting stop being ignored), it could not well convey a very true or satisfactory impression. So when we calculate the efficiency of various forces by the formula $f = mv^2$, we are simply transferring one v from the denominator of a fraction expressing the resistance, to the numerator of the quantity expressing the force, which we have a perfect right to do, provided that we recognize this as a *mathematical process*, and not as the expression of a *physical fact*. Our object in writing the above, is to make clear that this *is* the actual state of the case, and thus, in this and the other points noticed, to offer to those who may feel the appetite for such a supply, the reasoning which has satisfied in ourselves the craving after a rational account of things that had a certain air of paradox about them, as commonly enunciated.

THE DRYING PROPERTIES OF VARIOUS PAINTS.

From a Paper by Charles Tomlinson, F. R. S., read at the Society of Arts, Dec. 9th.

The question we have to consider is "Why does paint dry?"

VOLATILE LIQUIDS.—When we boil water a process of evaporation goes on, and the evaporation is not superficial merely, but from every part of the liquid. Again, if we apply heat to oil of turpentine contained in a retort, it will boil a little over 300 deg. Fahr., and the vapor may be collected and condensed in a cooled receiver; but if we try to boil linseed oil, for example, it will not only not distil over, but it will blacken and decompose instead of boil. If we moderate the heat so as not to carbonize it, then it will lose about one-sixth of its weight and become thick, tenacious, and viscid; forming what is called printer's varnish. Raise the temperature above 600 deg., and if air be present the oil will take fire and burn quietly without further external heating, until nothing but tar or charcoal is left. If, however, the burning be interrupted by closing the vessel, a brown viscid substance will be left, known as birdlime.

Turpentine belongs to a class of oils known as *volatile;* that is, they can be raised into vapour by means of heat, and under certain conditions will evaporate or dry up. Linseed oil, on the other hand, which cannot be distilled, belongs to a class of oils called *fixed.*

FIXED OILS, PAINTS.—House paint, omitting the coloring matters or stainers, consists of three ingredients: 1st, white lead or white zinc; 2d, a fixed oil, such as linseed or nut, used for the purpose of reducing the white to a soft paste, to which is afterwards added variable proportions of linseed or other oil for thinning the paint; 3d, the dryer. Dryers consist of litharge, oxide of manganese, and sugar of lead. Linseed oil is heated with about one-twen-

tieth of its weight of litharge, which the oil completely dissolves, and is then used as a dryer. A similar heating with manganese or sugar of lead also improves the so-called drying properties of the oil.

Oxidizing Oil—Experiment.—But what would be the effect of omitting the dryers altogether in the composition of the paint? I have no doubt most painters would say that the paint would never dry. Let us see the result of a careful experiment performed by Chevreul some years ago. Four oak strips were painted, each on one side, with a paint composed of white lead and linseed oil, and the other side with a paint composed of white zinc and linseed oil. The dryer was omitted in all cases. The strip No. one was exposed to the air to dry; No. two was put into a bottle of the capacity of 3.52 pints and closed; No. three was put into a similar bottle, containing dry oxygen gas; No. four was put into a similar bottle, containing dry carbonic acid gas. After 24 hours, No. one lead paint was almost dry; the zinc paint had set, but was not dry. No. two lead paint was almost dry; the zinc paint had set, but was not dry. No. three lead and zinc paints were perfectly dry. No. four paints were still wet and fresh, and had undergone no change. After seventy-four hours, Nos. one and two paints were perfectly dry. No. four lead paint had almost set, but it had no adhesion to the wood, and could be easily removed by friction; the zinc paint had undergone no change, but stuck to the finger like fresh paint. In another experiment it was shown that in drying in a confined volume of atmospheric air, the paint had absorbed all the oxygen, and left nothing but pure nitrogen in the bottle.

Paint dries, not because it loses anything, as in the case of ordinary drying by evaporation, but because it absorbs oxygen from the air, and solidifies in combining with it. The drying of paint, is not, therefore, a mechanical effect, as in the case of evaporation, but a chemical one, in which there is a change of properties attending a change of state from liquid or viscid to solid. Linseed oil exposed to the air in thin layers dries up into the form of a resinous, transparent, moderately elastic mass resembling caoutchouc. This property of absorbing oxygen and gradually becoming solid, also applies to walnut, hemp, poppy, grapeseed, safflower, and some other oils, and hence such oils are termed drying oils. In undergoing this change these oils undergo slow combustion, and give off carbonic acid. Under certain conditions the drying oils absorb oxygen so quickly as to take fire, as when the cotton-wool, tow, &c., used in cleaning machinery is thrown aside, and has thus led to conflagrations.

According to Mulder, the difference between non-drying and drying oils arises from the presence of oleic acid in the latter. He compares drying oils to blood; they absorb oxygen and give off carbonic anhydride. To prove this in the case of linseed oil, fragments of pumice stone were ignited, left to cool, and then put into a bottle, and the pumice was moistened with boiled linseed oil, the effect of boiling being to raise the oil into a state of greater activity. Air previously deprived of carbonic anhydride, was next passed over the pumice, and then into a vessel containing baryta water, which, in a few minutes became turbid from the presence of carbonic acid, due to the slow combustion of the oil. Roughly speaking, the setting of paint is due to the absorption of oxygen; hence we can understand why the painters, in order to prevent their brushes from getting hard, put them into water when they leave off work; and also cover a painted surface with water when they want to keep the paint from setting.

Non-Drying Oils and Paints.—The oils that do not absorb oxygen, are rape, colza, olive, almond, and many animal oils. By exposure to air they become gradually changed, but in a different manner as compared with drying oils. They become rancid from the fermentation of the cellular substance of the plant or animal from which the oil was obtained. They lose their color, and, to a certain extent their fluidity, and acquire an acrid, disagreeable taste. Such oils are, of course, quite unfit for the purposes of the painter, although there is ground for suspicion that linseed oil is sometimes adulterated with a cheap fish oil, the result of which in the paint is to produce a disagreeable kind of stickiness which is all but permanent.

Besides white lead, or white zinc, as the basis of paint, white antimony has also been proposed. In order to determine the relative merits of the three, M. Chevreul instituted an experiment in which ten grammes (154 grains) of pure linseed oil were mixed up with sufficient quantities of the three solids without the addition of any dryer. It was found that the zinc paint covered a

less surface than the lead, but more than the antimony paint. The drying of the different coats of the three paints required very different times, as will be seen in the following table:—

Coats.	Lead Paint. Days.	Zinc Paint. Days.	Antimony Paint. Days.
First	4	18	50
Second	3¼	15	28
Third	3	5	27
Total	10¼	38	105

Hence it appears that lead paint dries much more quickly than zinc or antimony paint. Indeed, unless it were possible to hasten the drying of zinc paint by the addition of a dryer, it would be of very little use in industry, since the practice of house painting requires that not more than two or three days shall elapse betwen the application of the first coat and that of the second.

Antimony paint is also too slow in drying to be used. A tin paint was also tried, but the oxide of tin was found to delay the drying of the oil. Pure linseed oil dries more quickly on glass than when mixed with oxide of antimony, so that this oxide is actually anti-siccitive relatively to glass.

Dryers.—We now come to the dryers, such as litharge, manganese, etc., and their action is very remarkable in causing the paint to absorb oxygen quickly and decidedly. For example—two cubic centimetres of linseed oil absorbed, in thirty days, 2.445c.c. of oxygen; but the same quantity of manganese dryer absorbed 21.45c.c. of oxygen; while a mixture of the two, consisting of 1.56c.c. of linseed and 0.44 of the dryer, absorbed 30.826c.c. of oxygen. That is, the absorptive, or, as a painter would say, the *drying* power of the mixture is far greater than the sum of the powers of the two oils, since 1.56c.c. of linseed oil absorbs of itself 1.985c.c. of oxygen, and 0.44 of the manganese dryer 4.719c.c. of oxygen in thirty days, the sum of the two absorptions being 6.714c.c. But the mixture really absorbed 30.826c.c., or more than four and a half times as much as the same fluids absorbed when exposed separately.

Experiments, scientifically conducted, have also shown, that, in preparing his dryers, the painter wastes both good materials, fuel and time. He boils his oil too long, and maintains the temperature too high. The usual mode of preparing dryers is to heat the linseed oil in an iron pot until it appears to boil. The surface is skimmed from time to time, and after from three to six hours, about one-tenth, by weight, of litharge is added, and the heat is maintained five or six hours longer; or 100 parts of very old linseed oil is heated about six hours, when six parts of litharge and about three of burnt umber are added. The heat is continued six hours longer, when the liquid, after being left quietly to cool, is decanted. For the manganese dryer, the oil is heated at the so-called boiling point during five hours; peroxide of manganese is thrown in, and the boiling continued for eight hours. We have already seen that the boiling is not the formation of vapor, but the escape of gas-bubbles due to decomposition.

Chevreul's experiments prove that pure linseed oil is more siccative after three hours' boiling than if not boiled at all; but is less siccative after five hours' boiling than after three. The oil boiled during three hours with one-tenth of litharge is much more siccative than if heated without the addition of this oxide; so that the drying property is not conferred on the oil by the action of heat, as some have supposed, but it is by the mutual action of the oxide and of the oil, assisted by a high temperature, that the drying properties are developed. Litharge is more siccative than manganese; and what is very curious is, that litharge, heated once with oil, is more active than fresh litharge. It is still more curious, that manganese that has been heated several times with the oil is more active than fresh manganese. But this excess of activity in the oxides is no longer exerted on oil that has already been boiled five hours. All the experiments proved that the drying property of linseed was injured by a prolonged heating at high temperatures; and the remarkable and unexpected result came out, that linseed, exposed to the temperature of from 100° to 176° Fah. during six hours in contact with ten per cent of manganese, can be used immediately in painting without the addition of any other dryer. Linseed oil alone, exposed to a similar moderate temperature, improves in its siccative property, but not sufficiently so to dispense with the manganese. A very energetic dryer is obtained by boiling the oil for three hours only in contact with fifteen per cent of the metallic oxide.

This completes the first branch of Mr. Tomlinson's paper. In the following number we propose to continue the subject of paints,

especially the drying of paints on metals, various woods and other substances, and the influence of turpentine and other ingredients.

RECENT RAILWAY WORKS AND PROJECTS.

Compiled from "Engineering," "The Practical Mechanic's Journal" and "The Engineer."

The great railway work of the year has undoubtedly been that across the plains and mountains of Western America—the Pacific Railway. The particulars of this work have been so often given that we need only say here that will form an unbroken line of railway communication across the continent from New York to the waters of the Pacific—a distance of over 3,000 miles, of which a few hundred miles only, await completion. It possesses, however, but little engineering interest beyond the fact that it crosses the two highest summits yet attained by railways, the summit in the Rocky Mountains being 8,242 feet, and that in the Sierra Nevadas 7,042 feet above the level of the sea, the mountains themselves rising considerably higher. These great elevations are, however, approached from such long distances, except on the Pacific slope, that there is nothing exceptional in the gradients or curves, nor are there any heavy tunnels or earthworks, nor important bridges. Indeed the "track laying" has gone on at the rate of three miles or more daily in each direction, and the line is expected to be open throughout in July next.

The most interesting line opened during the year is the temporary railway over Mont Cenis, overcoming a summit level 6,870 feet above the sea. On the Italian side the gradient for some considerable distance is one in twelve, while for a good deal of the distance on both the French and Italian slopes the inclination is at nearly the same rate. Upon all the inclines steeper than 1 in 40, in the whole line of 48 miles, a middle rail is laid in the very narrow gauge of 3 ft. 7½ in., and additional adhesion is obtained by means of horizontal gripping wheels, worked by the engine, and pressed with a force of from 5 to 15 tons against this mid rail. There are curves of two chains radius connecting the zigzags by which the line ascends the mountain. Of the working of the line and its prospects we have spoken elsewhere.

The Mont Cenis tunnel, and its progress we have recently described. The promised success of this undertaking has led M. Flachat, president of the society of Civil Engineers of France, to propose other lines across the Alps. After pointing out the daring rapidity with which all the rest of Europe has been furrowed by lines of railway, and showing that the territory of the Swiss Confederation is far behind the rest of the Continent in this respect as in others, he states that three great railway lines ought to be opened across the Alps, viz: by the Lukmanier, the St. Gothard, and the Simplon passes. While France is most interested in that of the Simplon, Germany is most so in Lukmanier. Switzerland is hostile to any line over the Simplon, because of its jealousy of France. Italy hails with pleasure any or all of them, having no choice except for whatever line shall enrich her most. M. Flachat after reviewing the success of the Mont Cenis tunneling, which is now about 1.9 meteres per day for each face of heading, and the probable improvements in tunneling machinery, concludes that tunneling in the Alps, upon a scale such as these and like vast ranges of mountains demand, is a matter of certainty now as to success, economy, and amount of cost, and that hence huge tunnels ought no longer to oppose the progress of the engineer in opening out such mountain barriers.

The particulars of the various tunnels proposed, compared with the Mont Cenis, are as follows:

Name of Tunnel.	Length. Metres.	Summit above sea. Metres.	Cost. Francs.
Mont Cenis.....	12,220	1,200	61,100,000
Simplon.....	12,080	1,300	60,000,000
St. Gothard....	15,480	1,110	78,000,000
Lukmanier.....	1,710	1,750	30,000,000

Without going through his figures, which are probably far from conjectural—for it is to remembered that the St. Gothard line, at least, was surveyed and laid out in detail some years ago—he arrives at the conclusion that the total cost of establishing the three great lines of passage, and placing them in full communication with the railway systems of the countries to the north and south of the Alps, would reach a total cost of 387,800,000 francs, or some $78,000,000.

Large railway undertakings are going forward in Russia, Hungary and Roumania; but in India and the colonies railways have made but slow progress. No active steps have been taking towards the construction of the Intercolonial Railway through New Brunswick, although the large loan for mak-

ing it was guaranteed by Parliament a good number of months ago, and half the loan has been taken up.

A railway has been at last begun across the Isthmus of Honduras, between the Atlantic and Pacific oceans. The length is to be 231 miles, overcoming a summit of 2,956 feet. The cost is set down at £8,000 per mile, but enough is known of the almost impenetrable forest and the unhealthy climate of Honduras to convince us that a far larger sum than this will be necessary.

An agitation, without any substantial results, was commenced, some months ago in Canada in favor of 3 feet 6 in. gauge railways. The whole scheme appears to have dropped through, and singularly, no particulars of the working and financial results of the same gauge on the Queensland railways have been furnished by the parties who have promoted other lines of the same gauge. A railway across Canada is proposed, which, if carried out, will absorb a capital of some $20,0000,000.

In Turkey there is a fine field for the construction of railways, and one scarcely inferior in China. *

As to French railways, there is an impression that it is because Government so limits them in extent that they all pay well, and that they are too few to accomodate the people. The list under survey or construction at the beginning of the year would seem to show that this want, if it exists, is being rapidly supplied. Among the principal new lines, are the following: Paris to Dieppe direct; Orleans to the sea by Honfleur, Lisseux, &c., 165 miles; Soissons by Buire, Vervens, Lugny, &c., to the Belgian frontier; Auch to Toulouse; Cercy-la-Tour to Grilly-sur-Loire; Cambray to Gannes; Niort to Cholet, 80 miles; Bergerac to Libourne; Méru to Beauvais; Flers to Conde-sur-Norreau; Avallon to Dracy-Saint-Loup; Aix to Marseilles; Epernay to Romilly; Napoleon-Vendeé to La Rochelle; Yevot to Dieppe; Havre to Lille; Bordeaux to Pauillac, and various branches of the Orleans and Rouen, and the Northern railways, and a line connecting the Eastern Railway of France with that of the Duchy of Baden, between Saint Louis and Leopold's Lake.

In Great Britain although the past year has not been marked by active railway enterprise, several important undertakings have been completed or carried forward. In and near London the principal works have been the Midland Extension, now open through to Bedford and the north; the Metropolitan and St. John's-wood, opened to the Swiss Cottage; the Metropolitan Extension, now completed to Westminster, and the new line of the South-Eastern, *via* Chiselhurst and Sevenoaks. The Midland Extension, with its four lines of rails and its great station at St. Pancras, is now one of the most important of all the railways out of London, and it may be expected not only to cheapen the transport of coal from Derbyshire, but almost literally to build up a new series of suburban towns extending even beyond St. Alban's. The St. Pancras station has been so often described, that it need only be noted that its magnificent iron roof has a clear span of 240 feet, the widest yet attempted, and that it forms altogether the finest example of railway architecture in the kingdom. The Metropolitan and St. John's-wood presents no striking features as an underground line, the ascent of one in 27 to Hampstead not having been begun. When completed, the line is to be 2¾ miles long and is to rise 235 feet above the level at Baker-street, three-fourths of a mile being inclined one in 27, with a station half way up. The Metropolitan Extension, has some very interesting work. The Metropolitan District Railway, under the Thames Embankment, has made but little progress as yet; nor is the East London, to be carried through the Thames Tunnel, far advanced. The new line of the South-Eastern, *via* Sevenoaks, is noteworthy for a considerable amount of tunneling, and for heavy earthworks, and also for some especially fine brickwork in its bridges. The London and Brighton Company have opened a new line between Brighton and Tunbridge, saving fifteen miles in distance. The London and North-Western Company's new line, *via* Runcorn, to Liverpool, was to have been opened at the end of the year, this line, as our readers are aware, crossing the Mersey on a long bridge, of which the principal portion consists of three pairs of lattice girders, each of 300 feet span. The Caledonian Company have made a new line over which trains are run between Edinburgh and Glasgow, without the *detour via* Motherwell, the distance being the same as by the old Edinburgh and Glasgow.

The increase of railways in the United States, and the principal railway engineering

* See article in another column on railways for China.

works—bridges, tunnels, viaducts etc—recently completed and in progress here and abroad were referred to in the February number of this Magazine. It is not improbable, that we are on the eve of an important reform in railway engineering especially in England, and that we shall have cheaper and competing lines, serving the public at half the present cost. As to the Goverment taking over the existing costly and extravagantly worked lines, it is at least as likely that Parliament, and more likely that Congress, will leave the whole question of railway reform to private enterprise.

THE STREET RAILWAY IN ENGLAND.—We long since predicted, says the "Railway Record," that its adoption in the suburbs, if not in the leading streets of our own metropolis, was only a question of time, and the act passed in the last session of Parliament authorizing the laying down of street tramways in the important and populous commercial city of Liverpool gave a *coup de grace* to an opposition which had contrived to interfere with the carrying out of a vast public convenience, which has been found to answer its purpose remarkably well in Salford, and in Staffordshire, and Birkenhead. The principal of the new companies seeking Parliamentary sanction is the Tram-way Company which proposes to form eight distinct lines in, and about London. Mr. Page the architect of Westminster Bridge has prepared the designs, and the traction will be conducted either by horse or by steam locomotives. There can be no doubt that every one of these will be opposed by the existing railway interests; and whether Parliamentary sanction will be obtained, will depend upon the temper of the new House.

On the other side of the question, Mr. Hulse, President of the Manchester Institution of Engineers says in his address on cheap railways, that unless the principal streets can be widened very considerably beyond what they are, unless people become accustomed to slow traveling, and unless the danger to which horses and other vehicles are subjected in crossing the rails is removed, I fear there will not be much likelihood of street railways becoming general. In some localities, and for some special descriptions of traffic, they may be found to answer tolerably well.

TEMPLE BAR, so long and nobly preserved by the Londoners, is at last to give way to the exigencies of street traffic.

THE CONSTRUCTION OF RESERVOIRS.

The failure of the Dale Dyke or Bradfield reservoir at Sheffield, England, in March, 1864, causing the loss of some 300 lives and immense damage to property, has led the authorities of many cities here and abroad, to look very critically into the construction and durability of similar works at their own doors. In view of the breaking of several pipes in the embankment of the Druid Lake at Baltimore, the water board of that city have called upon Messrs. J. R. Trimble, C. P. Manning and J. H. Tegmeyer, engineers, to make an examination of that work, and from their late full and able report, we extract the following interesting and timely facts and considerations.

CONSTRUCTION OF ANCIENT RESERVOIRS IN INDIA.*—Embankments in this country have been made without puddle trenches or puddle walls, the entire material of the banks being capable of resisting water. The earth was scraped up with rude instruments or by hand, carried in small quantities by men, women and children, trodden down by the feet of workers and animals, washed by monsoon rains, and dried and baked in the sun, until after many years of slow work, a close, homogeneous, enduring mound has been formed—instead of being thrown together in bulk from carts and cars, and inadequately tempered and compressed, as by the modern system. These works are remarkable for their vast extent. One has a bank 12 miles long and a reservoir circumference of 40 miles, the conduit pipe being 60 miles long. The reservoir of Abharya-Weva, is said to have been constructed 505 years B. C. It is now partially in ruins. The lake of Minery is 20 miles in circumference; the embankment is a mile long, covered with lofty trees. It is 2,000 years old and is still in use. The Cummum Tank is one of the earliest works, to which Hindoo history refers. Its length is five miles; its breadth three miles; its area eight square miles. The top of the bank or "bund" is 102 feet above the base with an average width at top of 26 feet; inside slope 3 to 1; outside slope 1 to $1\frac{1}{2}$ to 1. It has two culverts passing through it, and a waste weir of 230 feet width to carry off surplus water, but placed half a mile from the embankment.

* Mr. Rawlinson's report on the failure of the Dale Dyke Reservoir.

THE DALE DYKE EMBANKMENT.—This work for enclosing the waters of the Bradfield Reservoir, was situated in the ravine of the Dale Dyke or Loxley river, 6½ miles above Sheffield, and at a point 450 feet above that town. It was erected as a storage reservoir for supplying water power to mills and factories. The water-shed or gathering area discharging water in reservoir, is 4,300 acres. When full the lake had a surface area of 78 acres. Greatest depth of embankment 95 feet; capacity 114,000 cubic feet (855,000,000 gallons); top of embankment across valley 1,254 feet long; width of base 500 feet; width at top including four feet of puddle wall, 12 feet; inner and outer slopes of banks 2½ feet horizontal to one foot vertical; puddle wall or core inside of bank sixteen feet at a bottom and four feet at top, and 95 feet high; greatest depth of puddle trench or foundation of puddle wall below natural surface 60 feet The upper 40 feet of the embankment on both sides of the puddle wall, was composed of "rubble" materials by no means water-tight. The construction of the embankment was by railway wagons and carts, with tips, in layers three to five feet high, not saturated with water during the process, nor otherwise solidified. The materials were not of a good character for the construction of a water-tight embankment; and the mode of depositing and working it was objectionable. Two lines of cast iron discharge pipes eighteen inches diameter and 1¼ inches thickness, were laid under the embankment at a point 85 feet below its top. These were the only pipes in the reservoir.

The puddle trench descended various depths to the natural rock, or below it to impervious strata. Sinking the puddle trench was a tedious and costly affair. The springs in the strata through which it was sunk were so copious as to keep two steam pumps at work for two years, day and night. The waters of the river and of floods during this time, were diverted by a catch-water reservoir, and artificial channel on the side of the valley, to intercept and turn them from the excavation. This catch-water was afterwards broken by a freshet, which filled the reservoir to a depth of 50 feet in two days. An extreme flood on the area of 4,300 acres, draining into the reservoir would give a volume of 800 cubic feet per second; two pipes of eighteen inches diameter, 500 feet long, under a head of 90 feet, would discharge 84 feet per second from it. In extreme floods 30,000 cubic feet of water per minute, would flow into the reservoir; while both drain pipes and the waste-weir working free, would discharge but 19,000 cubic feet per minute; leaving a surplus of accumulated water of 11,000 cubic feet per minute, to threaten disaster. When the breach occurred at half past eleven, on the night of 11th March, 1864, the reservoir was full and a storm prevailing. The contents were discharged through the breach in half an hour, without any previous warning; passing down the valley at the speed of 18 miles per hour and sweeping all before them.

CAUSE OF THE FAILURE.—The two discharges pipes were laid in a cross trench, passing under the embankment and obliquely through the main puddle wall, at a depth of about 85 feet below its top, and at a point where the puddle trench was 30 feet deep below them. They rested in a puddle trench some 30 feet deep at the lowest point under the middle of bank, and were laid in puddle only. They were laid in a manner to almost insure destruction.

The puddle wall was too thin for a work of that magnitude. The material placed on each side of the puddle wall was of too porous a character, and much of it was tipped from railroad wagons, (directly into the embankment and not afterwards distributed), which is the most objectionable manner of constructing a water-tight embankment.

The objectionable mode of laying the outlet pipes, most probably fractured the puddle wall at the point of crossing; the loose state of the materials at the top of the bank let in the water; as the water rose in the reservoir, it most probably found it way down inside the puddle wall to the fracture above the outlet pipes, and hence the destruction.

CONCLUSIONS OF THE ENGLISH ENGINEERS.—Cast iron pipes should never be laid under such conditions as these. A culvert of masonry with an inner valve well, should have been provided. This culvert should have been on *solid ground in the side of the valley*, free from the loose earth of the embankment. Mr. Jackson, civil engineer, called in as an expert, said that he knew of a number of cases where pipes have been fractured, but of no grand disaster like this, of fractured pipes. He has laid pipes for twenty years, but would never again lay pipes *under an embankment in any way*, although *engineers have done so from Telford's time* down to this day.

The manner is which the bank was made is condemned. The layers should not have been over two feet thick, and should have been spread and consolidated with carts. The best clay puddle should not be trusted at less than one foot of thickness for each three feet of height of water. So that for an embankment 96 feet high, the puddle wall at the base should be 32 feet thick. At Bradfield embankment the puddle at the ground line was but sixteen feet in thickness, or one-half the strength required for safety. No puddle wall should be placed between masses of porous earth, but should be backed up on both sides with at least its own thickness of well selected materials, so as to prevent direct pressure from water on the inside, or any consequent cracking on the outside. The sinking of loose materials of earth on each side of a puddle wall may do mischief, unless such settlement takes place equally, evenly and slowly. A puddle wall should be wetted, worked and tempered into proper consistency. If the material on each side is not of the same sort and consistency, and does not set or build with the puddle, the bank is liable to injury.

If a deep trench continues to produce water, such water will soften the puddle and cause fracture of the puddle wall. Springs in the side of a puddle trench will inevitaly waste and wash such puddle, unless special means are provided to divert the water. Undisturbed strata may bear and resist water safely—when, if broken and disturbed by deep sinking and heavy continued pumping for the formation of a puddle trench, the whole strata may be so ruptured, washed and disturbed as never again to become sound. A perfectly homogeneous bank on a stable substratum is alone safe. A puddle wall may be "a delusion and a snare."

Conclusions of the American Engineers, on Puddling.—It is a matter of much surprise to any one not trained and educated in the English school of Hydraulic Engineers, to find so little improvement has been made in that country for the last hundred years in the mode of preparing and applying puddle material. The English adhere tenaciously, and often blindly, to old customs and to the practice of early and eminent engineers. The evidence taken before the coroner's jury shows that errors in plan and construction have been followed from Telford down to the present day—errors now admitted to be plain, though heretofore undiscovered.

The early English engineers used "cut puddling," called so from layers of clay cut out of carefully selected material by the spade and packed carefully in the puddle wall as carried up with wetting, but not thorough saturation, to bind the material into one mass. The method of puddling by throwing materials into water, or by flooding the material already placed, called "flood puddling," originated in the United States, and was probably used first on the Baltimore Water Works, or, if used in England it was unknown to American engineers. Its advantages have been so manifest in practice that in our opinion it is immeasurably superior to all other methods, and should be adopted to the exclusion of old processes. When we reflect that water exerts an agency everywhere in causing loose earth to take a compact form in our fields, roads and common embankments, it needs no labored argument to prove that there is no process which can so soon and so effectually bring a reservoir embankment to the required condition of homogenous compactness. It must all be alike in consistency, without any part subjected to the risk of being left dry and porous, to subside unevenly.

The Druid Lake Works.—The Druid Hill Reservoir is made in a dry ravine, with an area of less than 100 acres to gather floods. It will have a bank of 50 feet width on top, with an exterior slope of 2 to 1, and an interior slope of 4 to 1, giving a thickness at base of 650 feet. The embankment has a puddle wall of 95 feet extreme height above natural surface, or 119 feet above the lowest foundation of puddle trench; a thickness at top of 17 feet and 36 feet at bottom. The firm deposits of ages from the hills of Druid Park collected in the ravine, are mixtures of clay and gravel, constituting an impervious stratum, which was properly left undisturbed in the construction of the reservoir, except to remove vegetable matter, &c., to about one foot in depth. The puddle trench was but 12 feet in depth to impervious strata of rock in the bottom of the ravine, without any springs and but a slight filtration of water, in fact, dry. The formation of the embankment was from clay, earth and decomposed gneiss and disintegrated granite, the gneiss supplying a pure clay from decomposed feldspar, and gravel from the quartz and mica happily blended, so as to ensure impermeability by its adhesiveness, and solidity by its compactness and specific gravity.

As to the fracture of the pipes in these

works, and proposed changes, the report states: The first pipe fractured badly was the drain pipe, discovered twelve months after it was laid. In the fall of the same year (1866), the three influent pipes were found so badly injured as to render necessary their abandonment from prudential motives. The nature of the fractures were cracks at the bell-ends and from end to end and across the pipe, in some instances. These ruptures were first discovered by finding at a point just outside the embankment a small leakage of water discolored with iron. The roundness of the pipes was in some cases destroyed. Although these pipes were carefully laid in the manner frequently adopted elsewhere, yet four out of the seven have failed.

The engineers now consider the mode of laying these pipes objectionable, and their location under the bank injudicious. Pipes laid anywhere should rest on a foundation of perfectly uniform resistance, to preclude the possibility of unequal settling, which must fracture cast-iron. A perfectly solid basis would seem to be safest. The error committed was in laying part of the length in trenches and a part on piers. With so great a height of embankment above them, subsiding all the time, it could not be expected that either the pressure of the bank or the resistance of the foundations would be uniform. A slight difference in either would fracture the pipes. Those pipes remaining sound so far, must have had a uniform pressure upon them, or have presented a uniform resistance, so that no one part yielded more than another But as we now see from experience in England, it would have been better to insert all the pipes in the reservoir through *solid ground above the embankment and remote from the puddle wall.*

This change, suggested by Mr. Wendell Bollman, "will have to be made." The cluster of four pipes is to be carried, through solid ground at a level of 60 feet below the contemplated high water lines of the reservoir, built on carefully prepared foundations, and enclosed in stone and cement, with several projecting collars of masonry to check leakage and obstruct any flow of water.* Each pipe is to be enclosed in a brick culvert, fitting tightly its outer surface, so that when in time the iron is destroyed from any cause, the enclosing arch shall form a permanent conduit in place of the pipe.

* See on this subject, Hon. Wm. J. McAlpine's paper, Van Nostrand's Magazine, Vol. 1, No. 1, page 10.

ORDNANCE EXPERIMENTS—NEW ENGLISH BOARD.—In view of the complaints of inventors, the defenses of Ordnance Boards and officers, and the present excitement on these questions among persons interested in ordnance improvement, no less in America than in England, the following, from the "Army and Navy Gazette" will be of interest. For some time the Ordnance Select Committee has ceased to exist, and few will regret its demise. It had many enemies, and was regarded with suspicion even by those to whom it was most favorable. It was confessedly an expensive body in itself, and was the cause and origin of much expense in experiments which were often supposed to be instituted more with a view to investigate the mathematical and theoretical value of inventions, than their practical utility to the service. Since the Ordnance Select Committee received its death-blow, the constitution of its successor has been much discussed, and several attempts have been made to arrange its composition. These have mostly proved abortive, but we believe that the future tribunals before which both inventors and inventions will be arraigned have been practically settled. The present committee which is engaged in investigating Captain Moncrieff's battery, and the proper emolument to be conferred upon its designer, will probably decide all broad questions of the same kind in future. This committee is composed of the Parliamentary Under-Secretary of State for War, the Comptroller-in-Chief, the Naval Director of Ordnance, the Director of Works, the Director-General of Ordnance and the Assistant-Director; and its province is to decide broad questions and general principles.

To carry out experiments and inquire into details, either a special committee will be assembled, as has been done in the case of deciding upon the new breech-loading rifle, and the armament of field artillery for India, or, in less important cases, the matter will be submitted to the consideration of a permanent committee of inventions. The committee of inventions will be for the present composed of Colonel Milward, R.A., C.B.; Colonel Shaw, R.A.; Colonel Wray, R.A. (late Bombay Artillery); Lieutenant-Colonel Heyman, R.A.; with Captain Harrison as secretary. By this reorganisation of the duties of the Ordnance Select Committee, a great improvement will be probably effected, and great dissatisfaction will be remov-

ed; for there is no doubt that, justly or unjustly, the late Ordnance Select Committee was suspected by the outside world to be composed too exclusively of officers of scientific tendencies, interested in inventions, who were not inclined to view with favor or even impartiality, inventions which did not originate among their own adherents. The new Ordnance Board will, however, be far above any such suspicion; and, as its members sit *ex-officio* it is almost certain to remain so. A tribunal will thus be secured which will be, if not always satisfactory to inventors, open to no suspicion of favor, partiality or affection, while the country will find in it an adequate, completent and inexpensive arbiter of what is requisite for its necessities, as the members will receive no additional emolument for their services in this capacity.

THE HOLYOKE DAM.—The dam across the Connecticut River at Holyoke, Mass., having an unbroken length of upwards of 1,000 feet and with the water pouring over it in a massive sheet with a fall of 30 feet, has long constituted one of the most noteworthy of the many objects of interest in that portion of the country. The picturesque aspect is, however, doomed to be done away with, for the wear of the waters upon the soft rock at the base of the dam has hollowed it out to a depth of from six to eight yards, thus endangering the foundations of the structure and necessitating repairs which amount practically to thorough reconstruction, and which will change the waterfall into swift rapids shooting down an artificial inclined plane.

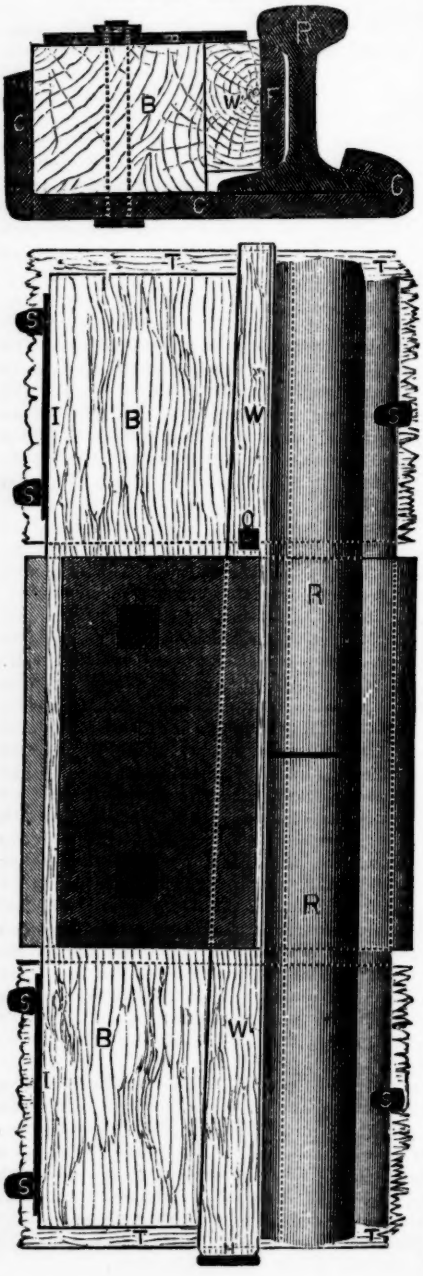
The process of repair is now being carried on with great energy, a portion 279 feet long at the centre of the dam having been already completed. For a distance of 50 feet down the stream, a series of timbers, locked and framed one over another, have been laid, and their interstices filled with stone. These from the bed of the stream rise to a height of twenty-five feet to the surface of the water. From the front edge of the substructure thus formed, the frame-work is continued with an inclined surface until it reaches the crest of the dam 30 feet above. This solid mass of stone and timber is covered with square logs a foot in diameter, and pinned fast to the timbers underneath; upon these are spiked maple planks four inches thick, which make the covering for the whole. The crest of the dam for a width of five feet is designed to be covered with three-sixteenths boiler-plate, of which not less than sixteen tons will have been used by the time the work is finished.

The portion or section of the dam of which we have just spoken has alone required about one million feet of lumber, eight thousand square rods of stone, and fifteen tons of bolts. The weight of the entire structure is estimated at thirty-three tons. The weight of that part of the dam is capable of resisting about four times the ordinary pressure of the water upon it.—*American Artisan.*

JAMES CHALMERS.—If the inventor of the best system of armor plating, could have enjoyed, while he was toiling for a trial of his scheme, a little more of that good English feeling and appreciation that the London newspapers are bestowing now that he is dead, it would have been better for all concerned. The system of backing armor plates by a cell-work of thin wrought iron plates, first introduced by Mr. Chalmers, has been improved only in size and detail, and is now the principle upon which every successful target is constructed. Mr. Chalmers' first target was not constructed at Government expense, but at the expense of Sir S. M. Peto. After its successful trial, says the "Army and Navy Gazette:" Mr. Chalmers suffered the mortification of seeing many of the essentials of his inventions copied and embodied in the recent additions to the Navy, without either acknowledgment or compensation; and, notwithstanding all his endeavors, he was never able, till lately, to prevail on the Government to get another target built embodying his invention, to be tried against a Government one of the same size and weight of metal. In this, careworn and wearied by official obstructions and delays, his naturally strong constitution gave way, and during the last eighteen months his health had been far from good, till at last he died on the 26th of December, at his residence in London.

Mr. Chalmers was also the author of a scheme of sunken channel railway, between England and France. His plan was, to have a tube of boiler plate, lined with brick, laid on the bottom of the sea, with ventilating towers at intervals; and the pamphlet which he published on the subject attracted general attention, and no small amount of criticism at the time.

FOSTER'S RAIL JOINT.



Now that the subject of maintaining the continuity of rails, is receiving general attention in this country, we shall publish from time to time, the particulars and results of such new devices as have been well tested, or are obviously practicable.

The joint fastening shown in the cuts, is the invention of Mr. Foster, Superintendent of the Logansport, Peoria and Burlington railway. It has grown out of his observation of the remarkable wear of several pieces of track which had to be laid in a peculiar manner owing to local causes; the rails were practically sandwiched at the joints, and have outworn several similar rails laid in the common manner. About ten tons of these joints have been under practical test during two years past on the road mentioned, also on the Chicago and Great Eastern, upon tracks used in common by the several roads centering at Logansport, also upon sidings where a large amount of shifting is done; locomotives run over the joints 200 to 300 times per day. The results are extremely satisfactory, when compared with all forms of chairs; the report does not state, however, whether it has been compared with the best of the modern fastenings. The lateral as well as the vertical continuity of the track is well preserved. A great saving in repairs is clearly shown. No stops, O, have been placed upon the wedges, but out of the whole ten tons, but two have got loose. Experiments have shown that the joint has less deflection under a passing load than the solid rail.

The most economical and effective form of splice, when the rail is suitably shaped, is the fish bar between the head and flange. How to keep the fish bar tight, has taxed the ingenuity of inventors for some twenty years. In this case, it is held up to the rail by an oak wedge, W, bearing upon the whole face of the fish bar, and hence not likely either to mash or to slip. With a rail of the form shown (in distinction from the low "pear head"), and a stiff clamp, C, the fish is certain to remain tightly wedged between the tables of the rail, and to be fully utilized. The lip of the clamp C is also wedged tightly upon the flange of the rail by the same wedge that secures the fish plate, thus realizing in some degree the advantage of the new Reeves' joint, which is a tight clamp upon

the flanges of the rail. The clamp C and the wooden longitudinal B also add a considerable resistance to deflection; but the chief office of the longitudinal is to form a backing for the wedge. The joint is suspended between two sleepers, thus giving ample elasticity, and also preventing the "creeping" of the track. Ths wood (oak) is seasoned, soaked in oil, planed, and carefully adjusted.

The best feature of this joint is the security of the fastening—the long wedge will not slip, though it may be readily set up; and its strength is a simple question of size of wedge and longitudinal. The joint is adapted to every form of rail, and may thus improve tracks that cannot be fished to advantage. It is well adapted to steel rails, because it requires no nicking or punching of the rails, either to prevent "creeping" or to hold the fish bar in place.

IRON ARCHITECTURE.—From a historical article on this subject in "Engineering," we gather the following facts: In 1783 Robert Ransome patented the application of cast iron, variously ornamented, to roofs. Twenty-five years later, Ralph Dodd obtained a patent for applications of iron to floors and to ship work, including hollow columns. Several patents followed for the substitution of iron for timber work. In 1811 Thomas Pearsall patented the use of iron skeletons—standards, joists, &c.—to be filled in with brick work. Ten years later iron beams were first employed for fire-proof floors, at a cotton mill in Manchester. In 1834 Pearsall's iron skeleton, covered with iron sheets, was applied in the erection of a gas works in London; and in 1842 Messrs. Laycock, of Manchester, constructed an iron palace, fifty feet by thirty feet, and three stories high, for the King of Eyamba, on the Calabar river. About this time Messrs. Gussell were making iron buildings for erection abroad; iron frames and corrugated sheet-iron covering, and shortly afterwards, the manufacture of portable iron houses largely increased. In 1845, Mr. W. Vose Pickett formed a company to erect iron buildings, and was the first to advocate the use of the cellular form of construction, and the ornamentation of pannels to resemble stone. But with the exception of the Great Exhibition buildings of 1851 and 1862, and a few large structures for special purposes, and some mere sheds without ornament, the use of iron for building—for street architecuture—has been singularly neglected in England.

In the United States, on the contrary, thousands of iron structures have been erected, and such is their design that iron façades can hardly be distinguished from stone. The first of these buildings was put up by Daniel D Badger, of New York, in 1842. In the following year A. L. Johnson, of Baltimore, introduced revolving iron shutters, and by a combination of these with iron posts, the lower stories of commercial buildings came to be generally made of the new material. About this time James Bogardus, of New York, was working succesfully in the same direction, and in 1847 he erected his lofty iron factory, which was subsequently taken down and re-erected, on account of the widening of a street. The Architectural Iron Works of New York and other American cities, are now very numerous, one of the latest and most prosperous being a branch of the Novelty Iron Works. Some 150 iron buildings appear in Broadway, and the use of this material appears to be largely increasing.

THE LEAVENWORTH BRIDGE.—A contract for the construction of a bridge over the Kansas river at Leavenworth, has been definitely concluded with that eminent bridge builder, L. B. Boomer, Esq. The bridge is to be completed for both railway and highway traffic in twelve months, at a cost of three-quarters of a million of dollars. The main bridge will consist either of three spans of 340 feet each, or four spans of 258 feet each, the superstructure to be of iron, upon the plan known as the "Post's Patent Inflexible Truss." The west abutment will be of first-class masonry; the rest of the substructure of cast iron pneumatic piles or cylinders, each 8½ feet in diameter, to be driven to the rock (about 60 feet below low water mark,) and carried up to the bridge seat, the whole height from rock to bridge seat being about 135 feet.

These columns are to be filled with cement and will be thoroughly braced to each other, and each pier will have an iron ice-breaker supported by another cylinder driven to the rock and brought up to low water mark. The approaches (about 4,000 feet long,) are to be built of wooden trestles.—*Chicago Railway Review.*

EXPERIMENTAL RESEARCHES ON THE MECHANICAL PROPERTIES OF STEEL.

By Wm. Fairbairn, L.L.D., F.R.S., &c.

From the "Quarterly Journal of Science."

The present may be justly considered the age of iron, as in every branch of industry where force, form, and motion are required, iron enters largely into construction, and its powers of application have supplanted almost every other material. It presents wonderful facilities in its adaptation to every description of art, whether of the useful or decorative style; and its improved tenacity, elasticity and ductility have enlarged its field of usefulness in the construction of buildings, ships, steam-engines, bridges, and machinery of all sorts where strength combined with lightness is required. To this powerful and valuable material we are indebted for railways, locomotives, and rolling stock; and there is no branch of manufacture in which it does not form a whole or a prominent part. Possessed of such a material in its cheapest and best forms, we should be deficient in duty if we left it in the rude state in which it was found in the days of Cort and his immediate successors. That great improvements have been effected of late years does not admit of doubt, and there is probably no material that has undergone greater changes in its manufacture than iron; and judging from the attempts that are now making, and have been made, to improve its quality and to enlarge its sphere of application, we may reasonably conclude that it is destined to attain still greater advances in its chemical and mechanical properties. The earliest improvements in the process of the manufacture of iron may be attributed to Cort, who introduced the process of boiling and puddling in the reverberatory furnace, and those of more recent date to Bessemer, who first used a separate vessel for the reduction of the metals, and thus effected more important changes in the manufacture of iron and steel than had been introduced at any former period in metallurgic history. To the latter system we owe most of the improvements that have taken place; for by the comparatively new and interesting process of burning out the carbon in a separate vessel, almost every description of steel and refined iron may be produced. The same results may be obtained by the puddling-furnace, but not to the same extent, since the artificial blast of the Bessemer principle acts with much greater force in depriving the metal of its carbon, and in reducing it to the state of refined iron. By this new process increased facilities are afforded for attaining new combinations, by the introduction of measured quantities of carbon into the converting vessel, and this may be so regulated as to form steel or iron of the homogeneous state, of any known quality.

The production of iron and steel in the homogeneous state is one of the most important improvements that has taken place since the process of rolling direct from the reverberatory furnace. The former process was first to melt the iron as it came from the smelting-furnace in the shape of pigs, to puddle it or to stir it about until the mass took the form of a ball deprived of its carbon; it was then placed under the hammer, and formed into slabs or ingots The next process was to roll it into bars, which being cut into short pieces, were again heated and rolled either into plates or bars as required.

Now the great defect of this process was the unsound state of the iron, as the least rust or scoriæ on the surface of the piled bars prevented the welding or fusion of the metals, and hence followed what are called blistered plates, or laminated bars of unsound construction.

The new process, it will be observed, obviates all these difficulties, as in the Bessemer process the melted iron is deprived of its carbon by the action of an artificial blast—the same as formerly prevailed on the hearth of the refinery—and thence it is cast into ingots of the weight required, either for the hammer or the rolls. From this it will be seen that the risk of piling and welding is entirely dispensed with, and the article produced, whether of iron or steel, is perfect in its homogeneity. It may be of good or inferior quality, hard or soft, but by this process it is free from the risk of being unsound in its homogeneous state.

As regards the steel, of which we have to submit the results, as produced by the principal manufacturers of this country, it will be observed that in making steel from the puddling-furnace, similar combinations may be produced, but with less certainty as regards quality, as everything depends on the skill of the operator in closing the furnace at the precise moment of time, before the mass is deprived of its carbon. This precaution is necessary in order to retain the exact quantity of carbon in the puddled ball, so as to produce by combination the requisite quality

of steel. It will be observed that in the Bessemer process this uncertainty does not exist, as the whole of the carbon is volatilized or burnt out in the first instance; and by pouring into the vessel a certain quantity of crude metal containing carbon, any percentage of that element may be obtained in combination with the iron, possessing qualities best adapted to the varied forms of construction to which it may be applied. Thus the Bessemer process is not only more perfect in itself, but admits of a greater degree of certainty in the results than could possibly be attained by the mere employment of the eyes and hands of the most experienced puddler. Thus it appears that the Bessemer process enables us to manufacture steel with any given proportion of carbon, or other eligible element, and thus to describe the compound metal in terms of its chemical constituents.

Important changes have been made since Mr. Bessemer first announced his new principle of conversion, and the results obtained from various quarters bid fair to establish a new epoch in metallurgic manipulation, by the production of a material of much greater general value than that which was produced by the old process, and in most cases of double the strength of iron.

These improvements are not exclusively confined to the Bessemer process, for a great variety of processes are now in operation producing the same results, and hence we have now in the market homogeneous and every other description of iron, inclusive of steel, of such density, ductility, etc., as to meet all the requirements of the varied forms of construction.

The chemical properties of these different kinds of steel have been satisfactorily established; but we have no reliable knowledge of the mechanical properties of the different descriptions of homogeneous iron and steel that are now being produced. To supply this desideratum, I have endeavored, by a series of elaborate experiments, to determine the comparative values of the different kinds of steel, as regards their powers of resistance to transverse, tensile, and compressive strain.

These experiments have been instituted not only for those engaged in the constructive arts, but also to enable the engineer to make selections of the material as will best suit his purpose in any work proposed. In order to arrive at correct results, I have applied to the first houses for the specimens experimented upon, and judging from the results of these experiments, I venture to hope that new and important data have been obtained, which may safely be relied upon in the selection of the material for the different forms of construction.

For several years past, attempts have been made to substitute steel for iron, on account of its superior tenacity in the construction of ships, boilers, bridges, etc.; and there can be no doubt as to the desirability of employing a material of the same weight and of double the strength, provided it can at all times be relied upon. Some difficulties, however, exist, and until they are removed it would not be safe to make the transfer from iron to steel. These difficulties may be summed up in a few words, viz: the want of uniformity in the manufacture, in cases of rolled plates and other articles, which require perfect resemblance in character, and the uncertainty which pervades its production. Time and a close observation of facts in connection with the different processes will, however, surmount these difficulties, and will enable the manufacturer to produce steel in all its varieties with the same certainty as he formerly attained in the manufacture of iron.

In the selection of the different specimens of steel, I have endeavored to obtain such information about the ores, fuel and process of manufacture as the parties supplying the specimens were disposed to furnish. To a series of questions, answers were, in most cases, cheerfully given, the particulars of which will be found in the experimental tables, published in the Transactions of the British Association for 1867.

I have intimated that the specimens have been submitted to transverse, tensile, and compressive strain, and the summaries of results will indicate the uses to which the different specimens may be applied. Table I. gives for each specimen the modulus of elasticity, and the modulus of resistance to impact, together with the deflection for unity of pressure; from these experimental data the engineer and architect may select the steel possessing the actual quality required for any particular structure. This will be found especially requisite in the construction of boilers, ships, bridges, and other structures subjected to severe strains, where safety, strength, and economy should be kept in view.

In the case of transverse strain some difficulties presented themselves in the course of the experiments, arising from the ductil

nature of some part of the material, and from its tendency to bend or deflect to a considerable depth without fracture.

But this is always the case with tough bars, whether of iron or steel, and hence the necessity of fixing upon some unit of measure of the deflections, in order to compare the flexibility of the bars with one another, and, from the mean value of this unit of deflection, to obtain a mean value of the modulus of elasticity (E) for the different bars. This unit or measure of flexibility given in the table, is the mean value all the deflections corresponding to unity of pressure and section. In order to determine the resistance of the bars to a force analogous to that of impact, *the work* in deflecting each bar up to its limit of elasticity has been calculated. These results differ considerably from each other, showing the different degree of hardness, ductility, etc., of the material of which the bars are composed. The transverse strength of the different bars up to their limit of elasticity is shown by the amount of the *modulus of strength* or *the unit of strength* calculated for each bar.

Table II, on Tensile Strain, gives the breaking-strain of each bar per square inch of section, and the corresponding elongation of the bar per unit of length, together with the ultimate resistance of each bar to a force analogous to that of impact.

Table III, on Compression, gives the force per square inch of section requisite to crush short columns of the different specimens, with the corresponding compression of the column per unit of length, together with the work expended in producing this compression.

It will be observed from the following tables that the results of the experiments show that the deflections produced by a transverse strain are in proportion to the pressures within the limits of elasticity.

In Table I, as in the other two on tension and compression, the value of the work done on each specimen has been determined, and the results recorded in the last column indicate the comparative strength of each particular bar; and the mean value of the deflections corresponding to unity of pressure and section will be found in column 3. These may be taken as the measure of flexibility, elasticity, and ductility of the different bars, and the uses to which the material may be applied.

The mean value of E, the modulus of elasticity taken for thirty of the best specimens, is about 31,000,000, which exceeds that of wrought iron by more than the thirtieth part. Steel having a much greater flexibility than malleable iron, accounts for the approximation of their respective values in D. This arises from the fact that the bars of the greatest flexibility—other things being the same—have the least value for the modulus of elasticity.

On tensile strain the mean result derived from thirty of the best specimens is 47.7 tons, or nearly 48 tons per square inch; and in this, as in the previous table, the measure of ductility and strength is given in the last column, which indicates the ultility of the material and the purposes for which it may be selected.

Comparing the best quality of steel with the best wrought iron at 24 tons as the breaking-weight per square inch, we find that we have a material of double the strength with the same weight, or what is the same thing, of only half the weight with the same same strength, or as 47.7 to 24. In the art of construction these are considerations of great importance; and in every case where steel can be depended upon, it is entitled, on the score of economy and lightness, to the judgement and practical knowledge of the architect and engineer.

In Table III, on compression, each of the specimens were reduced, when cut from the bars previously experimented upon, to small columns of $\frac{3}{4}$ inch diameter and 1 inch in height. They were each loaded with weights equal to 100 tons per square inch, without undergoing any sensible appearance of fracture. On consulting the table it will be found that with the above weight of 100 tons per square inch they were compressed, on the average, to two-thirds their original length; and from these facts we were enabled to find the value of u, recorded in the last column, as the value of work done by the load which produced the change of form in each of the specimens submitted to pressure. This, it will be observed, was the true test of the powers of resistance of the respective specimens to a compressive strain, and the conditions under which materials of similar properties may be safely applied in constructive art.

On comparing the mean tensile resistance to rupture at 47.7 tons per square inch, it will be seen that the resistance to compression is more than double the resistance to extension, or as 100.7 to 47.47, being in the ratio of near 2:1. Hence it follows that the most economic form of a steel bar un-

COMPARISON OF STEEL MANUFACTURED AFTER THE BESSEMER PROCESS WITH THAT MANUFACTURED BY OTHER PROCESSES.

TABLE I.—*Transverse Strain on Inch-square Bars, and 4 ft. 6 in. Between the Supports.*

MANUFACTURER.	Description of steel.	Mean value, D_1, of the deflection for unity of pressure and section.	Mean value of the modulus of elasticity E.	Mean work of deflection, u, for unity of section.	Mean value of C, the unity of working strength.	Remarks.
					Tons.	
Messrs. J. Brown & Co...	Bessemer steel,	·0012739	30,730,000	52·721	5·918	Mean breaking weight, 1,000 lbs.
Messrs. C. Cammell & Co.	Bessemer steel,	·0013518	29,166,000	59·897	5·921	Mean breaking weight, 950 lbs.
M ssrs H. Bessemer & Co.	Bessemer steel,	·0016684	29,813,000	49·489	5·659	Mean breaking weight, 975 lbs.
The Hæmatite Steel and Iron Company.....	Bessemer steel,	·0014590	27,153,000	26·463	3·914	Soft steel.
Mean.....	.....	·0014382	29,215,000	47·142	5·283	
Messrs. Naylor, Vickers & Co	Melted in the crucible	·0013007	30,278,000	65·049	6.548	
Messrs. S. Osborn & Co..	Melted in the crucible	·0014296	27,482,000	52·574	5·622	Mean breaking weight, 1,250 lbs.
Messrs. C. Sanderson & Brothers.....	Melted in the crucible	.0013209	29,973,000	47·411	5·521	Mean breaking weight, 1,250 lbs.
Messrs. T. Turton & Sons,	Melted in the crucible	·0013120	30,294,000	52·680	5·886	Mean breaking weight,
The Titanic Steel and Iron Company.....	Mushet's steel,	·0012350	31,901,000	63·542	6·435	1,200 lbs.
Mean.....	.....	·0013196	30,042,000	56·251	6·002	

TABLE II.—*Tensile Strain on Bars ¾ inch Diameter—Elongations Taken on 8 in. Length.*

MANUFACTURER.	Description of steel.	Specific gravity.	Mean weight laid on in lbs. producing rupture.	Mean breaking strain per square inch of section.		Mean elongation, per unit of length.	Mean value of u, or work produe'g rupture. By eq. 13.
				Lbs.	Tons.		
Messrs. J. Brown & Co..	Bessemer steel.....	7·7665	33·603	90,379	40·35	·0460	2002
Messrs. Cammell and Co.	Bessemer steel.....	7·8119	34·085	101,132	45·14	·0595	2714
Messrs. Bessemer & Co...	Bessemer steel..	7·7726	38·189	89,955	40·15	·0753	3212
The Hæmatite Steel and Iron Company	Bessemer steel.....	7·7951	33·321	72,195	32·22	·0942	3351
Mean.....	....	7·7891	34·299	88,415	39·46	·0682	2819
Messrs. Naylor, Vickers & Co.....	Melted in the crucible,	7·8198	39·449	108,099	48·25	·0372	1827
Messrs. S. Osborn & Co..	Melted in the crucible,	7·7758	44·151	103,214	46·07	·0341	1842
Messrs. C. Sanderson & Brothers.....	Melted in the crucible,	7·7563	39·502	95,553	42 65	.0229	1566
Messrs. T. Turton & Sons,	Melted in the crucible,	7·7990	39·295	93,380	41·61	·0165	807
The Titanic Steel and Iron Company.....	Mushet's steel.....	7·7883	37·179	93,616	41·79	·0551	2413
Mean.....	....	7·7878	39,923	98,772	44·07	·0327	1691

COMPARISON OF STEEL—Continued.

TABLE III.—*Compressive Strain on Specimens ¾ in. Diameter and 1 in. in Length.*

MANUFACTURER.	Description of steel.	Mean weight laid on in lbs.	Greatest weight laid on per square inch of section.		Mean compression per unit of length.	Mean value of u, or work expended in crushing the bar.
			Lbs.	Tons.		
Messrs. J. Brown & Co.....	Bessemer steel.....	91,840	225,568	100·700	·347	39,101
Messrs. C. Cammell & Co.....	Bessemer steel.....	91,840	225,568	100·700	·339	38,232
Messrs. H. Bessemer & Co.....	Bessemer steel.....	91,840	225,568	100·700	·379	42,720
The Hæmatite Steel and Iron Co...	Bessemer stlel.....	91,840	225,568	100·700	·445	50,207
Mean.....	.....	91,840	225,568	100·700	·377	42,981
Messrs. Naylor, Vickers & Co.....	Melted in the crucible,	91,840	225,568	100·700	·286	32,300
Messrs. S. Osborn & Co.....	Melted in the crucible,	91,840	225,568	100·700	·267	30,014
Messrs. C. Sanderson & Brothers....	Melted in the crucible,	91,840	225,568	100·700	·328	36,906
Messrs. T. Turton & Sons	Melted in the crucible.	91,840	225,568	100·700	·398	29,254
The Titanic Steel and Iron Company,	Mushet's steel.....	91,840	225,568	100·700	·315	35,551
Mean.....	.....	91,840	225,568	100·700	·318	32,805

dergoing a transverse strain would be a bar with double flanges, having the area of the top flange about one-half that of the bottom.

This conclusion is borne out by the results of experiments on transverse strain, where S_1, the strain per square inch of the material at the elastic limit, $= 6\ C = 6 \times 6.83$ tons $= 40.98$, or 41 tons nearly; but the mean breaking-strain per square inch by extension $= 47.7$ tons, clearly indicates that the compressive resistance in the former case was considerably in excess of the tensile resistance.

It is important in every experiment on the strength of materials, which enters so largely into constructive art, that we should be thoroughly acquainted with the properties of the material of which the structure is composed, and that its resistance in all the different forms of strain should be clearly and distinctly ascertained. In the foregoing experiments we have determined the resisting powers of the different specimens to bending, tension, and compression; but we have omitted that of torsion, or twisting, until we have an opportunity of doing so upon the same identical bars. These I hope to accomplish at some future period, and also to give some further results upon an enlarged scale, calculated to confirm what has already been done, and to ascertain some additional facts in regard to the changes now in progress in the manufacture of Iron and Steel.

THE PNEUMATIC DESPATCH.

This thoroughly practical, speedy and cheap means of transporting parcels, if not passengers, having been placed under a temporary cloud by the financial difficulties of the London Company that are building it on the largest scale, is is about to be revived and pushed to completion. Says "Engineering": Some five years ago the Pneumatic Despatch Company commenced the construction of a line from Euston station to Holborn, and thence to the General Post-office. The first length, from Euston square to Holborn, was completed in the autumn of 1865, and in the October and November of that year many experimental trains were despatched through the tube with success. The experimental working, however, lasted for a weeks only, and eventually, pecuniary difficulties arising, the works were closed. Things remained in this state until a few weeks ago, when arrangements were made to complete the line. The length from the Euston station to Holborn is $1\frac{3}{4}$ miles, while a short length has also been laid from the Holborn station eastward, and this latter length is now to be extended to the General Post-office.

For the greater part of its length the line consists of cast-iron tubes 4 ft. 6 in. wide by 4 ft. high, these tubes being made in 9 ft. lengths, and the joints between them being caulked with lead. Besides curves of moderately large radius the line comprises a curve of 170 ft. radius, at the corner of Drum-

mond-street and the Hampstead-road, a similar curve where the line turns eastward at Broad-street, St. Giles's, and a curve of 70 ft. radius where it enters the Holborn station. On these curves the tube is constructed of brickwork.

At the Holborn station are situated a pair of horizontal engines with 24 in. cylinders and 20 in. stroke, which work the fan 22 ft. in diameter, by which the air is exhausted from and forced into the tubes. The trains will be drawn from the termini to the Holborn station by exhausting the air in the tube, and forced from the Holborn station to the termini by the opposite process. The carriages, or trucks, are carried on four wheels, and their ends are shaped so that they almost fit the tube, the slight clearance allowed being partially closed by projecting strips of sheet india-rubber. The suction main is connected with each main tube at some distance from the end, and the carriages, on passing the mouth of the suction tube, have their motion arrested by the cushion of air formed between them and the doors, by which the end of the main tube is closed. At the proper moment these doors are opened by a self-acting arrangement, allowing the train to pass through. At the Holborn station the ends of the two main tubes, the one from Euston and the other (which is yet to be completed) from the Post-office are situated side by side, and a traverser is provided by which the trucks can be rapidly transferred from the one tube to the other. It is expected that the total time occupied in the transit from the Euston station to the Post-office will be about from 13 to 15 minutes; the time occupied by the experimental trains in running from Euston station to Holborn being 7 minutes.

Of the progress of a similar work in New York, the "New York Times" says that a company of English capitalists, have obtained a charter from the Legislature and have commenced to construct a pneumatic dispatch-tube in the lower part of the City, for the conveyance of parcels and letters, and it might be, passengers also. Mr. Moses Beach, the president of the company, hired the basement of the Messrs. Devlin's store, corner of Broadway and Murray-street, as a starting point for the line, with the intention of carrying it to the vicinity of the Nassau-street Post-office. The work of tunneling beneath Broadway then begun, has been slowly but steadily progressing, and will be pushed forward to completion as soon as possible. The details of the company have been carefully withheld from the public, in order to avoid the otherwise inevitable annoyance of injunctions from stage-line proprietors and property-owners on the route.

Vis Viva.—"With a double velocity the moving (railway) train passes over double the space each second, and therefore encounters twice as many points of resistance. Moreover, it strikes each of these points with double the velocity, and hence meets at each point twice the resistance. It therefore meets, during a second, twice as many points of resistance, and suffers at each point twice as much resistance. The resistance, during a second, is thus four times as great as before, and must require four times as much force to overcome it. In order to obtain three times the velocity it would be necessary to increase by nine times the force; and in general the force required will be proportional to the square of the velocity to be obtained. What is true of the motion of the train of cars is true also of the motion of a steamboat through the water, and indeed of any motion on the surface of the earth, since all such motions encounter resistance. Hence the work accomplished by a force is proportional, not to the velocity, but to the square of the velocity, which it imparts to the moving body." (Cook's Chemical Physics, page 52.) Prof. Cook continues, upon such a basis, to explain *vis viva* and *momentum*. Most of the school-books on physics and natural philosophy present the subject in a similar way, and we have quoted from Cook's Chemical Physics simply because it is a work of the very highest repute for accuracy of statement of facts and theories, and therefore cannot be objected to as a representative.

In our present judgment the statements above quoted are not sustained by reason or experience. It is very far, indeed, from true, as a question of fact, that the power required to maintain a train or a ship in uniform motion varies as the square of the velocity; there is really no such mathematical relation, and there is no close approximation to it; moreover, the case of a ship is so different from that of the train that many engineers who strive to measure facts on a procrustean bed of simple mathematical formulæ, represent that the power required to drive a ship varies as the cube of the velo-

city; and no experienced engineer will say that within ordinary limits of speed four times as much power is ever required to maintain a train at double velocity. Professor Cook indeed represents that the resistances in a double velocity are doubled at each point, but this is surely an assumption, and is not warranted by experience. The resistances to a train in motion are mainly friction, and the air to be pushed aside; the friction is nearly proportioned to space and not to velocity, while a law of the resistance of the air is practically indeterminable. Now we have to suggest that the confusion and mystery of the subject, at least so far as the theory is concerned, are avoided by considering the work done as the measure of force or power. If we wish to determine only the *quantity* of effective force concerned in a movement, it is quite independent of time or velocity; the raising a pound of matter one foot implies always the same amount of moving force, power, or actual energy, whether it has occupied an instant or an age. Double work imples double power; to grind two bushels of corn requires twice the power to grind one. When resistances to motion are uniform, the space gone over measures the work and the power irrespective of time and velocity. If in any case the total quantity of resistance varies with velocity, then the power to maintain uniform motion will vary with the square of the velocity; but is there really such a case in nature or in art? A locomotive engine makes a certain number of strokes (excepting the slip) per mile, whether moving fast or slow. which represent the same number of cylinders full of steam, and, except for the resistance of the air, the cost per mile of running would be nearly the same for all velocities.

It should be noted that we carefully distinguish the cases of maintaining a uniform motion and the changing of velocity. In case of regular change (acceleration or retardation), as in the free fall of bodies by gravity, the spaces gone over are a measure of kinetic energy and vary with the square of the velocity; for example, to double the acquired velocity requires quadruple the power. It requires about four times the space and four times the steam to attain from rest a double velocity of a locomotive, but when the velocity is attained we have done with the ratio of the squares. The principle of *vis viva*, as we understand it, applies only to the changing of volocity.—*Chemical News.*

BREAKING IRON AND STEEL MASSES.

"Armengaud's Génie Industrille" through "Dingler's Polyt. Journal." Translated by John B. Pearse.

Pieces of cast iron of considerable size are extremely difficult to break up, and necessitate colossal air furnaces in order to melt them without breaking. The following method of breaking up large pieces has been practiced successfully at the works of Petin and Gaudet in Saint Chamond. Powder is often used to divide large masses, but aside from the necessary caution, its use is difficult and it often does not accomplish the desired effect. The following method, invented by M. Montandon, manager of the above works, is quite easy to apply, and not at all dangerous. It consists in using the force, which confined water exerts (when struck), in every direction upon the material in which it is enclosed.

A round hole two to three inches in diameter and ten to twelve inches deep is bored in the mass to be split; this hole is then filled with water and closed by a closely fitting steel cylinder upon which the drop is allowed to fall from the usual height. The mass is thereby split into several pieces, as if by a strong wedge with several faces. The water cannot escape and its endeavor to do so bursts the metal. In this way a plate roll of 29½ inches diameter was split, in presence of the French editor, into four or five pieces, which flew 20 to 30 feet away from the drop.

The hole must be hermetically closed and in order to do this thoroughly it is necessary to hollow out the base of the steel cylinder into a cup shaped form, the edges of which are driven against the walls of the hole by the water in its efforts to get past. To allow the air under the pin to escape, it is well to file a small screw-shaped grooved on the latter, when it can be driven down quite easily.

A single blow of an ordinary drop usually suffices to split off pieces of 30 to 36 inches in diameter. A pin of good steel can be used several times. This method is obviously easier than the use of a large drop falling a great distance and is much more certain in its effects.

SANITARY ENGINEERING.—In addition to watering and draining towns, the engineer is now called upon to provide fresh air artificialiy—to ventilate not only buildings, but whole towns. This subject was mentioned by Dr. Rumsey, in a recent address to the National Association for the promotion of social science, in England.

IRON AND STEEL NOTES.

INFLUENCE OF THE OXIDES OF CHROMIUM AND TITANIUM ON THE COMPOSITION OF PIG IRON.—Within the last four years we have been frequently employed in chemical investigations of the altered characters of some pig irons, which resulted apparently under the usual circumstances in the reduction of uniform ore. In these cases the amount of carbon united with the iron had been diminished, without the introduction of other matter in quantity sufficient to influence a change in this connection, and generally no variation in the composition of the ore was known or suspected. We had analyzed the ores in some of the beds in former years, and regarded them as well adapted to the production of pig iron of good quality; but, in pursuing the research, we were convinced that the change in quality of iron could be traced to altered composition in the ore of part of the beds used for supplying the furnaces.

The correctness of this view was confirmed by our analyses of many iron ores, in some of which we found the oxides of chromium or titanium, existing where they were not indicated and connected with the ore in beds which have been considered as pure iron ores. Both the oxide of chromium and oxide of titanium seem to act in the furnace or the crucible in a way to withdraw a portion of the carbon, or prevent that true union of carbon with a portion of the iron, which constitutes gray pig iron, without the metals of these oxides really alloying with the iron and thus indicating the cause of change. We have analyzed samples of pig iron where the alloys of chromium or titanium existed in the pigs, and where the oxides accompanied the ores in the beds, but we were not prepared to find an influence exerted on the quality of the pig metal *without the refractory metals forming a part of the composition.*

The occurrence of oxide of magnese with iron ore is common, and titanium compounds are often found in both magnetic and brown iron ores, as insoluble substances, in small proportions, and these compounds combine with and are removed by the fluxes without injury to the pig metal. These compounds of titanium are the cause of the often superb blue color of the cinder, produced under varying conditions of glassy or stony character, and must be carefully distinguished from those we regard as more detrimental in their influence on the metal.

In a number of analyses of iron ores we had found both oxide of chromium and oxide of titanium in a state rendering them soluble in diluted acids, and in a condition to escape detection in the ordinary modes of analysis. Both magnetic and brown iron ores have been found to contain either oxide of chromium or oxide of titanium in this soluble state. Among the samples from contiguous beds, this diversity in composition made by the presence of some oxide of chromium or oxide of titanium existed; and while the bulk of a bed of ore was pure, continuations of the bed, or associated ore, yielded notable weights of oxide of chromium or oxide of titanium in the different samples.

The suggestion we would make to the iron master in view of these facts is, the possibility of the quality of the pig metals in anomalous cases being greatly influenced by the admixture of some ore containing the oxides of chromium or titanium, with the bas's ore of good quality. This may take place by the main bed being crossed by veins of mixed ore, or by the workings passing into contiguous beds where one kind of ore is used. In other cases, where the iron master can gain the great advantage arising from mixing ores, one of the kinds may contain the contaminating oxides and injure the iron.

We subjoin some results of analyses showing the proportion of oxide of chromium to the metallic iron contained in the ore: 1st. Magnetic ore—iron, 49; oxide of chromium, 1·40. 2d. Hematite ore—iron, 42·47; oxide of chromium, 1·60. 3d. Brown Massive ore—iron, 64·32; oxide of chromium, 1·90. 4th. Same—iron, 46·70; oxide of chromium, 1·04. More traces have been discovered in some cases, while in other instances a larger proportion of chromium formed an alloy with the iron produced from the ore. —Aug. A. and S. Dana Hayes, Assayers to State of Massachusetts.—*Railway Times.*

MANUFACTURE OF IRON DIRECT FROM THE ORE. —At the Ringgold Iron Company s Works, in Pennsylvania, an improved process of manufacturing wrought-iron, the invention of Mr. J. Jameson, has for some time past been in successful operation. The furnaces are somewhat of an oven-shape, having, however, a stack from the top of about twenty feet in height. A refining fire is in front, into which the blast-pipes enter on the side. The gas that is evolved from the fuel passes into a chamber, where combustion takes place, and thence the combustion of the gases continues till above the fifth chamber it passes (together with such deleterious qualities as have been taken up from the ore in its progress) through and out of the stack. The five chambers are called in the Jameson patents the deoxidizing chambers. The ores are calcined, then crushed, and first placed in the top or fifth chamber. Into the first and second chambers a small jet of steam is injected, whereby hydrogen is generated for the purpose of aiding in desulphurizing and dephosphorizing the ores. The floor of the top chamber is a table made of fire-clay blocks, with an opening at the end opposite from the door or entrance through which the raw ore is thrown in. On this table the ore is spread out, and after being subjected to the operation of the burning gases, it is then pushed down through the opening at the end of the table opposite to the door on to a like table in the chamber below, where it is again spread out, and here it remains for a time and in like manner passes on to the table of the third chamber; there, after undergoing a like operation, it is passed to the second chamber, thence it goes to the bottom or the first chamber. Thus every particle of the ore is equally operated upon. By this time the ore is almost a pulp, and then it is passed into the charcoal bed and refining chamber. Here the loop is soon formed, when it is taken out, and the hammer soon presents you with a bloom of from 225 to 250 lbs. weight. It is well known that the blooms produced by the direct processes are of inferior quality, whilst a very large quantity of ore and fuel is used in their production. With the Jameson process these difficulties are avoided—a ton of blooms being produced with the same quantity of ore and fuel as is now employed to make a ton of pig metal in the blast furnace. The production is stated to be unfailingly uniform.—*Mining Journal.*

CASTING STEEL UNDER HIGH PRESSURE by means of gunpowder, is thus described by the inventor: It is well known that cast steel run into moulds is subject to blister and is otherwise porous, which defect reduces considerably its toughness. In order to give this metal its requisite tenacity it is subsequently re-heated and then rolled or hammered. As many articles, such as cannon, cannot be treated in this manner, I have devised to submit them to a high pressure whilst in a liquid state, enclosed in their same moulds, maintained in iron flasks. For this purpose, immediately after running a cannon, I cover hermetically the head by a metallic cap, by means of bolts or other devices attached to the flask. This cap is fitted in its center with a vertical pipe, and provided with a cock at its lower extremity, whilst its upper extremity is closed by a washer pressed by a bolt in such manner as to act as a safety valve. Before attaching the cap, at, supposing, one

inch from the surface of the liquid metal, I introduce in the vertical pipe, and between the cock and the washer, a charge of about one quarter of an ounce of a powder, prepared in the proportions of eighty parts of saltpetre and twenty parts of charcoal. On opening the cock this powder falls on the metal, ignites and engenders about one-third of a cubic foot of gas at 3,000 Fahr. These gases exert on the liquid metal a pressure which is transmitted throughout the entire mass, thereby condensing the same and expelling the blisters. The effect thus produced is equivalent to the pressure of a head of liquid metal ninety feet high, admitting that the capacity between the cap and the surface of the metal contains thirty cubic inches. By making the flasks sufficiently strong, the charges of the powder may be varied, so as to produce by its ignition a uniform and general pressure, which is preferable to the partial, irregular and momentary action of a hammer.

NEW BLOWING ENGINES FOR THE WIGAN COAL AND IRON COMPANY.—These engines blow air into ten blast furnaces, through a wrought iron tube seven feet in diameter, the blast being delivered at a pressure of about four pounds to the square inch. Before entering the furnaces, the blast is heated to from 800 to 1,000° Fahr. The furnaces have closed tops, in the usual manner. To each furnace there are four hot blast stoves. The present number of boilers put down is ten, double-flued and ranged in front of the engine house, which is a magnificent structure, with a tower at least 100 feet in height. The machinery is from the works of Messrs. Nasmyth, Wilson & Co., of Manchester. There are three engines, with six blast cylinders, and six high and low pressure steam cylinders. The diameter of the air cylinders is 100 inches; of the high-pressure steam cylinders 45 inches; and of the low-pressure steam cylinders 66 inches. The stroke of each engine is 12 feet. All the steam cylinders have steam jackets; also the exhaust pipes between the high and low pressure cylinders. The engine beams are 36 feet from center to center. Each pair of engines has two blowing cylinders; each blowing cylinder is above each steam cylinder. The engines being worked by high and low pressure, the high cylinder is connected with the low one by two side levers and beams, already referred to. The working apparatus is in duplicate, worked from one end, so that both cylinders are worked by steam valve gear; this valve gear is worked by an entirely new motion, patented by Mr. Robert Wilson. The air to supply the blast is conveyed into the engine house through a tower and an underground tunnel.

IRON AND STEEL INSTITUTE FOR GREAT BRITAIN. — At the preliminary meeting of this organization lately held in London, Mr. Isaac L. Bell, of Middleboro', in the chair, it was resolved to ask the Duke of Devonshire to be the first president, 1st, because Englishmen are very fond of having a nobleman at their head; and, 2d, because the Duke, in addition to having great possessions in mineral property, is at the head of a concern which is amongst the foremost and the most extensive of modern iron and steel works in England.

The following subjects were suggested as proper for the consideration of the Institute:

Iron Ores.—Details of newly discovered deposits of iron ores; analyses of various English and foreign ores; mode of occurrence; cost of working; probable extent of deposits; distribution of ores; ironstone mining.

Blast Furnaces.—Calcining kilns; use of furnace gases for calcining; blast furnaces—modes of construction; best proportions of various classes of minerals to be used; engineering arrangements; blowing engines; hoists; utilization of furnace gases and furnace slag; heating stoves; tuyeres; casting arrangements; generation of steam; construction of chimneys.

Conversion of Pig into Wrought Iron.—Improvements to save expense of re-heating pig-iron; improvements in puddling and heating furnaces; fettling; mechanical puddling; simplification of converting processes; methods of arranging forges most effectively; utilization of waste heat from furnaces; selection of materials for different classes of finished iron; mill work; arrangement of different kinds of mills; details of manufacture of rails, plates, bars; special sections; new application of iron.

Foundry Work.—Special qualities of various kinds of pigs; cupolas; improvements in melting furnaces, and in arrangements for moulding with rapidity and certainty; testing iron.

Steel.—Relative merits of various plans for the production of steel; manipulation of cheaper brands of iron for steel making; applications of steel.

Metallurgy.—Solution of numerous disputed points in connection with the metallurgy of iron and steel; verification of Bunsen's and Playfair's experiments; improved methods of practical and expeditious analyses of iron; purification of iron from deleterious elements; further examination of the properties of the alloys of iron; influence of magnetism upon iron and its alloys at various temperatures.

Miscellaneous.—Statistics of the position and development of the iron and steel manufacture in this and other countries; reports on special features of foreign iron-fields and iron and steel works.

PHILADELPHIA AND READING RAILROAD COMPANY'S ROLLING MILL. — This mill is eligibly situated about two miles north of the Reading City passenger station, at the point where the East Pennsylvania railroad diverges from the main trunk. The mill-house is 413 feet in length by 93 feet in width, with a spacious wing projecting from one side. There are twelve puddling furnaces, eight heating furnaces and two re-heating furnaces. There are two trains of 23-inch three-high rolls. The finishing train is two-high. The rails rolled are of three weights—64 pounds, 62 pounds and 56 pounds per yard—for use in localities according to character of traffic. The rails contain about one-third part new iron.

The housings and bed-plates of the trains were made by Matthews & Moore, of Philadelphia, and are not only heavy and strong, but very accurately fitted. This accuracy of workmanship, such as characterizes the best marine engineering, is new, but equally important in rolling mills, and is a feature of Matthews & Moore's work to which we have previously referred in speaking of their machinery at the Pennsylvania Steel Works, and at the Abbott Mill in Baltimore. The saw machinery of the Reading mill is by the same builders. The engines are by George W. Snyder, of Pottsville, the work being surpervised by J. E. Wootten, Engineer of Machinery for the P & R. R.R. Co. All the boilers, castings, furnaces, &c., were made at the company's shops in Reading. The general plan, and the details of the parts not otherwise specified above, were made by Mr. W. E. C. Coxe, and the whole was erected under his superintendence, and is run under his able management. The carrying out of Mr. Coxe's plans was entrusted to Mr. Samuel Stroh, the present foreman of the mill.

The capacity of the mill was recently tested as follows: During twelve hours, 92¼ tons (2,240 lbs.) of rails (405 bars of 64-lb. rails) were produced from eight heating furnaces; these were all heated a second time after blooming in two re heating furnaces, giving an average of 46¼ tons for each of the latter. The product of the mill in January was 1,437 tons of finished rails.

GALVANISING IRON.—DRAWING OFF THE OFFENSIVE VAPORS.—The application of zinc with tin as a coating for iron, has become a most important manufacture in and about Birmingham. The application of iron for every purpose of construction is practically only limited by the difficulty of preserving the surface from rust. No method has yet been adopted which is at once so cheap, so effectual, and so enduring as galvanizing, and the works in which that process is carried on have very rapidly increased. To galvanise iron it is immersed for a certain period in an acid to cleanse the surface, after which it is dipped into a bath containing zinc and tin melted. In this salts of ammonia are thrown, which operates on the metal as a solvent, and enables it to be more evenly distributed over the surface. From this bath is given off a dense, pungent, white-colored vapor, which is heavy, and, especially in damp weather, spreads and becomes offensive. Complaints have been made of these vapors, and various plans have been adopted for the purpose of preventing them from passing into the atmosphere, but heretofore without success. The Wolverhampton Corrugated Iron Company have adopted a plan which is found very effectual. The top of the bath is surrounded by a flue which forms a projecting lip, and from this run one or more iron pipes communicating with a powerful fan. From the fan a large flue extends to an annealing furnace. The fan, by creating a vacuum in the pipes, causes a strong current of air to pass over the surface of the bath, which drives the vapor into the furnace, where it is entirely consumed. Experiments are in progress to condense the vapors so as to utilize them, instead of consuming them in fires.

CLEVELAND ROLLING MILL.—The works of this company were first established in 1857 for the manufacture of railway and merchants' bar-iron, since which time their capacity has been constantly increased. In 1859 the first blast furnace was built; afterwards, in 1864, the mill of the Railroad Iron Mill Company was bought and furnished with new machinery, and a second blast furnace erected. The two furnaces are now making from 45 to 50 tons per day, and the two rail mills have a capacity of 35,000 tons of rail per annum. The bar iron mill is capable of making from 12,000 to 14,000 tons per year. The company commenced the manufacture of Bessemer steel in September, 1868, with one five-ton converter, and are at present turning out some fifteen tons per day. They are now putting up another five-ton converter and erecting reverberatory furnaces and cupolas, which will enable them to increase the capacity of steel production from 40 to 50 tons per day. The greater portion of the steel has been made into rails, which have thus far shown the best results. The Bessemer steel made by this company has been very even in quality. The works are situated near the best iron-producing region of the country—the Lake Superior region—the ores of which are remarkably well adapted for producing steel by the Bessemer process. Besides turning out steel and iron rails of good quality, they manufacture beams, girders, merchants' bar, boiler rivets, fish plates, spikes, nuts, bolts and a variety of other articles used in railway construction and repairs. The works are favorably situated, having water and rail connections with the whole west and northwest.—*American Railway Times.*

FIBRE OF WROUGHT IRON.—In a paper read before the Liverpool Pol technic Society, "On the Structure of Metals," Mr. Vivian stated that the "fibre" or "silky lustre" exhibited in the fracture of good iron is only the effect of the light reflected from inner surfaces of myriads of minute cells exposed by the fracture, that the form of these in their normal state is spherical, or nearly so, but they become changed in the process of rolling, &c. Air has no access to these cells in their concealed state, but when they are exposed to the action of the atmosphere they soon become tarnished. The cellular construction is not an accidental occurrence, but it is the proper constitution of the metal, and appears to take place under the combined effects of heat, the repellent force, and the coherent force inherent in the substance. The mechanical properties of tenacity, ductility, &c., must greatly depend on the perfection of the cell system, and as much importance should be attached to this as to the degree of chemical purity necessary to insure a good iron, since it is well known that from iron of the same chemical purity various qualities of metal may be produced by working at an i proper temperature, or by cooling too suddenly.

PLANT AND OPERATIONS AT FIRTHS' STEEL WORKS.—Dr. Percy thus refers to the works of Messrs. Firth & Sons, of Sheffield, in a letter to the London "Times:" For casting large ingots each crucible contained about 50 lb. of molten steel. At a given signal the pouring of the metal commenced, and in sixteen minutes the ingot mould had received the contents of the 212 crucibles. There was no bustle or confusion. The men, 200 in number, knew their drill, and did their duty without a hitch. The ingot weighed 86 cwt., and was designed for the steel tube of an Armstrong gun. The receptacle employed by Krupp for receiving the steel from the crucibles, in the first instance, was dispensed with; but that is only a point of minor detail. The Messrs. Firth have cast nine-ton and sixteen-ton ingots. A nine-ton ingot is required for the 23-ton Armstrong gun. Messrs. Firth have expended about £30,000 in the erection of two 25-ton Nasymth hammers, re-heating furnaces, on Siemens' principle, and other appliances. The anvil block of each hammer is cast iron, cast in one piece, and weighs 164 tons. The length of hammer stroke is nine feet six inches.

THE SIEMENS FURNACE is being somewhat extensively applied for puddling, and so far as has been reported, with good results, there being not only a saving of fuel, but a very considerable saving of iron, while also the balls, especially if fettled in rich ore, are of better quality. The importance of the highest quality of fettling material is very great where the iron to be puddled is largely charged with phosphorus. Some of the Cleveland ironmasters puddling highly phosphuretted pig, import large quantities of a very pure ore from Norway and Sweden, and these, used as fettling, not only add a large quantity of iron to the charge, but they take up a large proportion of phosphorus or phosphoric acid in the slag; and the puddled bar, which would otherwise be very cold short, is found to be fine grained, ductile, and fitted for nearly all the purposes of good makes of bar iron.

STEEL RAILS AND TYRES.—Messrs. William Bird & Co. in their monthly circular speak as follows of the relative use of steel for tyres and rails in England and on the Continent. They say: "Compared with foreign railway specifications for 5,000, 6,000 and 8,000 tons of rails, and 5,000 to 8,000 and 10,000 Bessemer steel wagon tyres on a line, our home requirements of a few tons at a time (Bessemer steel rails in the proportion of 200 tons to 5,000 tons of wrought iron are just now advertised by the Great Northern) appear quite insignificant, and in the course of the past year there have been contracts of 40,000 tons given out to French works for both Bessemer and Martin rails, and 5,000 tons of French make have even found their way to the United States lines."

MACHINE PUDDLING.—In this direction nothing ing appears to have been done since the unsuccessful attempts made at Dowlais, and those, still earlier, by Mr. Tooth and Mr. Yates. Nor do we learn that the revival of a former attempt to introduce air directly within the iron in the puddling furnace, by means of a tubular rabble with a flexible air pipe, has made any progress. This mode of introducing air was heard of some little time ago, as "the Richardson process." So, too, there was "a Radcliff process" of knocking four or five puddled balls into one, and rolling or forging them direct into a single large bar. There were obvious objections to this mode of working, that especially of the risk of unsound welds, and the saving of a single heat is not enough to compensate for this risk, so fatal to the product.—*Engineering.*

TEMPERING TAPS.—A correspondent of the "Scientific American" writes as follows: Most of your readers are aware of the difficulty in tempering taps and reamers without springing, especially long and large ones. To accomplish this let the blacksmith select his steel for the job and forge the tap with a little more than the usual allowance, being careful not to heat too hot, nor to hammer too cold. After the tap or reamer is forged, heat it and hold it on one end upon the anvil. If a large one, hit it with the sledge; if a small one, the hammer will do. During this operation the tap will give way on its weakest side and become bent. Do not attempt to straighten it. On finishing and hardening the tap will become perfectly straight. If any are doubtful, a simple trial will convince them.

ATLAS WORKS, BESSEMER PLANT, GLASGOW.—These works are fully illustrated in "Engineering," Jan. 1. A pair of three-ton vessels are arranged in the ordinary English style. There are two air furnaces and two cupolas, capable of holding the whole charge; also two spiegel furnaces. The charges are elevated by hydraulic hoists. There are two independent pairs of blowing cylinders, with twenty-inch steam and 2 6-inch air cylinders of two and one half ft. stroke, making seventy revolutions. The converters have cast-iron trunnion hoops. There is nothing new in the design. The American works have greater facilities, and can produce a larger product with the same number of vessels.

THE RICHARDSON PROCESS OF PUDDLING.—This is reported to be gradually maturing in England, and several improvements are announced. The blowing out of the silicon sparks through the stopper-hole has now been overcome by the employment of a hooded rabble. It is said that at the Parkhead Works, near Glasgow, where the process has been in operation nearly a year, not a bad bar has been produced. At Messrs. Palmer's Works, Jarrow, the use of the tubular rabble has been supplanted, Mr. Ridley having introduced a method of injecting the blast through the pipes introduced through openings at the side of the furnace, and excellent results are said to be produced by this method.

FIRE-BRICK IN STEEL MAKING.—An exchange states that many works are erecting in this county for the manufacture of steel rails, and that one of the steel furnaces will use a million fire-bricks a year! This can hardly refer to the Bessemer Works, where no fire-brick are used, except to line the nose of the converter, and for the spiegel furnace, which will last a couple of years. The Siemens furnaces are probably as durable as ordinary reverberatory furnaces, and we can hardly imagine a steel process in which brick alone will cost say ten dollars per ton of product.

STEEL RAILWAY CARRIAGES.—The recent report of the Oude and Rohilkund Railway Company, states that the steel rolling stock, which had been the cause of some anxiety to the board, was very likely to turn out a complete success. They had, at present, two long metal carriages, capable of accommodating 200 passengers each, and were found to be very suitable for the traffic. The remainder of the steel rolling stock, for which a supply of wheels and axles had been forwarded, was now being made available.

IMPROVED ROLLING MILL MACHINERY.—Messrs. Thomas Perry & Son, of the Highfields Works, Bilston, have made a train of 24in. rolls, three high, for rolling steel rails. They have also just completed a universal mill for rolling long narrow plates without shearing. This kind of rolling is effected by the addition of vertical rolls behind those which are horizontal, and it is a plan which has been for some time most successfully worked on the Continent. (See article on universal mill, in another column.)

WASHING COAL.—Since the expiration of the patent for the French coal-washing machine, so long held by Mr. Morrison, of Ferry-hill, it is coming into extensive use, and with the best results. Worthless "slack" is now powdered, its pyrites separated, and it is afterwards coked into excellent fuel at an almost insignificant cost. In France and Belgium great attention is paid to washing refuse coal, and the adoption of the French mode would save vast sums of money here.

TROY BESSEMER STEEL WORKS.—The steel works of Messrs. John A. Griswold & Co., burned in October, are being rebuilt by Mr. A. L. Holley, late superintendent of the Pennsylvania Steel Works. The two-ton converter has been at work all winter, producing some ten tons of ingots daily. The five ton plant will be considerably enlarged, and will be running in July. A new blowing engine, the largest Bessemer engine in this country, is building by Messrs. Paulding, Kemble & Co., Cold Spring.

REMARKABLE PRODUCTION OF A CHARCOAL FURNACE.—From January 1st to 31st inclusive, the Irondale furnace of E. Harrison & Co., produced 784 tons of pig-iron of 2,268 lbs. to the ton. The daily average was therefore 25¼ tons. This is a charcoal furnace measuring 9½ feet in the bosh, and 40 feet in height, and uses nine-tenths Iron Mountain ore.—*Bulletin of the Am. Iron and Steel Association.*

THE SPECIFIC GRAVITY OF STEEL oscillates between 7.2 and 7.9. The hardening of the metal by tempering is accompanied, as Réaumur long ago observed, by a notable diminution of specific gravity; and M. Caron has noted that the specific gravity of steel diminishes with the number of times it is tempered.

NEW FURNACE OF THE STERLING IRON AND RAILWAY COMPANY.—A new blast furnace building for this company, after the designs of Mr. Rumpff, of the West Point Foundry, is 60 feet high, with 12 feet boshes.

LARGE ROLLS.—A pair of rolls for Sir John Brown's Works, Sheffield, recently cast at the Phœnix Works, Bilston, were of the following dimensions:—Length of roll 15¼ feet, diameter 3 feet; weight, 18 tons.

HIGHEST BLAST FURNACE IN THE UNITED STATES.—The Port Henry furnace, 70 feet high, with 16 feet bosh, is stated to be the highest American furnace.

RAILWAY NOTES.

RATE OF PROGRESS OF THE MOUNT CENIS TUNNEL.—During the past year an advancement of 1,320.15 meters has been made at the Mount Cenis tunnel, of which 638.60 was driven on the Italian side, and 681.55 meters on the French. The advancement has been 110 meters per month, or 53.20 on the Italian side, and 56.80 on the French; and at this rate of progress the time necessary for the completion of the tunnel would be twenty-eight months, or about April, 1871, and for opening the railway about six months more, or in less than three years.

The following table, from "Engineering," shows the yearly progress that has been made with these works since their commencement in 1857:

Year.	Bardonnèche.	Modane.	Total Advancement.		Expenditure.
			Each Year.	At end of Year.	
	meters.	meters.	meters.	meters.	francs.
1857.	284.85	212.75	497.60	497.60	3,369,000
1858.					
1859.	236.35	132.75	369.10	866.70	1,630,000
1860.	203.80	139.50	343.30	1,210.00	3,000,000
1861.	170.00	193.00	363.00	1,573.00	2,500,000
1862.	380.00	243.00	623.00	2,196.00	2,000,000
1863.	426.00	376.00	802.00	2,998.00	3,500,000
1864.	621.20	466.65	1,087.85	4,085 85	6,552,000
1865.	765.30	458.40	1,223.70	5,309.55	5,502,000
1866.	812.70	212.29	1,024.99	6,334.54	5,644,000
1867.	824.30	687.81	1,512.11	7,846.65	6,000,000
1868.	638.60	681.55	1,320.15	9,166.80	7,500,000
	5,363.10	3,803.70	9,166.80	.....	47,197,000

ENGINES, WORKING AND EXPENSES ON THE SEMMERING RAILWAY.—At a recent meeting of the *Société des Ingénieurs Civils*, M. Gottschalk, locomotive engineer of the South Austrian Railway system, stated that the successive improvements in traction on these lines, and especially on the Semmering section, up to the end of 1865, had not only been maintained, but had still continued to progress in 1867. Passing over the results of 1866, which were abnormal in consequence of the war, the expenditure on the entire system, Semmering included, had been 0.977f. per train kilometer, as against 0.992f. for 1865. For Semmering alone the cost of traction in 1865 had been, for those trains that could be taken up entire, 1.70f. per train kilometer, and for goods trains divided and taken up at two trips, 3.40f. In 1867 these figures were reduced to 1.666f. for the single train, and 3.33f. for the double train. These reductions would have been greater but for the work to replace in proper condition the overworked rolling stock of the year of the war, and the unusual quantity of snow during December. It may then be affirmed that the already so greatly reduced expenses of traction on the Semmering and other lines are not, as some persons think, the consequences of its recent construction. Locomotives in use last above eighteen years; their repairs are placed to the current account, as well those of vehicles of all kinds. Damage to rolling stock, often considerable, caused by foreign service, is always borne by the traction service. The radius of 189 meters in the Semmering curves prevents the use of two locomotives to the train without danger, but this obstacle does not exist on the Brenner line, and the company has been authorized to run its trains of 350 tons across in one journey by means of two locomotives, one in front and the other in rear of the train. Besides complete security in case of any breakage in the coupling, this plan offers obvious advantages, which it is unnecessary to specify. One great difficulty in working the Brenner line is the means of regulating the speed in the descent. The proportion of brakes sufficient on the Semmering with curves of 189 meters is not so on the Brenner with curves of 300 meters, although the inclines are the same on both lines. The Semmering line is double, the Brenner single; the consequence is a marked difference in adhesion. These difficulties are to some extent overcome by the use of sand, but though it is largely employed it is insufficient. The descent was therefore an occasion for the use of reverse steam, for which purpose all the Brenner locomotives have been provided with the Le Chatelier apparatus, similar to that adapted to the Mediterranean locomotives.

The new goods engines, on the same general principles as the modified ones of the Semmering, with the entire mechanism and exterior appurtenances, give the best results. The maximum weight of the goods trains last winter reached 369 tons. Here the gross weight of each train became

Weight of wagons	369 tons.	
" 2 locomotives—94,600 kilos..	131	"
" 2 tenders—36,400 kilos.....		
	500	

Multiplying this weight by 6 + 25 kilos. we find that the tractive power developed is 155,000 kilos., and that the work of these two engines at a speed of 15 kilos. per hour is about 850-horse power, or 425-horse power per engine. Under these circumstances vaporization is not forced, as each square meter of heating surface only equals two and a half horses.

RAILWAY PROGRESS IN RUSSIA.—The first railway in the empire was opened in 1838, and for seven years it was the only one. One or two short lines were opened in the course of the next two years, but, in 1848, a line was opened from Warsaw to the Austrian frontier. It was not until after the death of the Emperor Nicholas that railway enterprise made any very great strides in Russia. Since then, however, the process has gone on upon an accelerating scale. There are at present 5,960 versts of line open, 3,337 versts are in course of construction, and a Council of Ministers has decreed concession for eight new lines, declared to be indispensable, the gross length of which is 3,235 versts. The majority of the lines opened have been constructed with foreign capital, and the funds for the new undertakings are sought for from the same source, and there is now a full stream of English capital directed from home projects flowing into Russia to enrich that country, and to increase the strategic power of the Czar.

The following are the lines in course of construction: Kiev-Balta (all that remains to be completed of the Moscow-Odessa line), 428 versts; Odnoga-Berdeyzeff, 27 versts; Odnoga-Wolocsysk (Polesia-Bukowina), 167 versts; Tiraspol-Kischeneff (Bessarabia), 65 versts; Kursk-Charkoff-Taganrog-Rostoff (Moscow and Taganrog line), 763 versts; Jelets-Orel (continuation of Grias-Jeletz), 173 versts; Orel-Witepesk (last portion of the line connecting the St. Petersburg-Warsaw and St. Petersburg-Moscow-Odessa lines, open to Rostavl, four-fifths of the distance), 493 versts; Grias-Boryssogleb (extension of the South-Eastern in the direction of the Volga), 192 versts; Kaslov-Tambov (extension of the South-Eastern in the direction of the Volga), 74 versts; Odnoga-Schuya, 84 versts; Troizka-Yaroslav, 196 versts; Poti-Tiflis, 284 versts; Moscow-Smolensk (direct connection between Moscow and the Riga-

Dünaberg-Orel line), 391 versts. Total, 3,337. Of the Russian lines fifteen have a government guarantee, and their capital amounts to 237,856,000 roubles.

Few of the Russian railways have, as yet, managed to become self-supporting, and Englishmen are warned by newspaper correspondents to keep clear of the railway mania, now at its height. The government is understood to have suffered some heavy losses on account of its guarantees, but it can afford to stand many more, if necessary to the development of the country.

Differing from the standard adopted in most European countries, the Russian gauge is five feet, an arrangement intended to prevent foreign railway carriages from entering the country in peace, and still more in war. Only in Poland the ordinary German guage of four feet eight inches has been adhered to. A weak side of the Russian railways is the insufficiency of their rolling stock, which, being almost entirely imported from abroad, is a dear commodity, and, in consequence, kept at a low figure. Accidents are not very common, Russian engine-drivers, who are apt to indulge their liquorous propensities, being discarded on many lines in favor of steady Germans. Yet, as the number of passengers is small, the death-rate by accident is necessarily great. *From Correspondence of the London Times.*

EFFECT OF NORTHERN, EAST AND WEST LINES UPON NEW YORK CITY.—This subject is discussed at length in "Harpers' Magazine;" the conclusions are as follows: Upon the completion of the Hoosac tunnel, Boston will have two lines direct to the lakes. The line by way of Springfield encounters an elevation of 1,450 feet above tide, and, in its ascent towards the west, has a grade of 83 feet to the mile. The line by way of the tunnel rises at the summit to 1,106 feet, and passes through the tunnel at an elevation of 838 feet above tide; but it has no grades steeper than 58 feet.

New York enjoys the benefit of tide-water from Troy to the ocean, and of a railway whose steepest grades (at Poughkeepsie) are only fifteen feet. The Harlem road is less favorably situated for carrying through freights, as it is obliged to pass over the same mountain range through which the Hudson River makes a clean sweep. Except for about 104 days in each year, when the river is closed with ice, New York has the immense advantage of the Hudson river, capable of floating the largest barges at rates for freight with which railroad lines cannot compete, and at all times it has two lines of railway. In extending her enterprises to Lake Ontario, it will be impossible for Massachusetts to secure the advantage which the New York Central enjoys in passing through the Allegany at the dip at Little Falls. The road and canal there are about 300 feet lower than Lake Erie, and but about 100 higher than Lake Ontario, whereas the line suggested for competition must pass over the mountain at unfavorable grades.

New York has the inestimable advantage of a canal and line of railroad which *descend* from Lake Erie to tide-water, with the exception of a trifling counter-elevation, and has only 110 feet to overcome between tide-water and Canada. If New York had no road but the Erie it would be on a footing with the Atlantic sea-ports south, as its grades are about on a par with those encountered by them. Pennsylvania, Maryland and Virginia are obliged to surmount elevations in the neighborhood of about 1,500 feet. North and South Carolina have high and nearly impassable mountains behind them; but South Carolina avoids hers by using the roads of Georgia, which are constructed around them and through an opening at Chattanooga in another range. The history of the Erie railroad will be relied upon by many to prove that it was a great error in policy not to confine ourselves to *the route indicated by nature* for our canal and great lines of railway. Washington was the first to point it out when in command of the revolutionary forces located in the valley of the Mohawk, and the first to express the hope that it would be improved. His education as an engineer enabled him at a glance to perceive that New York stood unrivaled in her facilities for intercourse by land and sea, and consequently for commercial supremacy.

ITALIAN RAILWAYS AND WORKS.—The public attention is so much directed to the Mont Cenis tunnel that the works upon subordinate portions of the great line connecting the northern and southern sides of the Alps are little noticed. Upon the Italian side of the mountains there is much difficult engineering. The line from Bardonnèche and Bussoleno, 25 miles long, has a tunnel three-fourths of a mile long, and several fine bridges at Meana, a succession of lesser bridges on the whole line, and no less than 24 tunnels in all. A line 40 miles long from Gloia and Tarente has many features of great difficulty, requiring "trial sections" and careful preliminary reconnoissances before any attempt could be made to delineate the approximate route. An iron bridge over the torrent San Stephano, has a central span of 180 feet, and is 200 feet above the water. A viaduct over the Castellancla is 240 feet high from the river. This is an iron structure on lattice-work iron piers. The character of the structures on these lines is highly spoken of by experts.

The Italian railways in operation at the close of last year was as follows:

		Kilom.
Alta Italia Railway Company:		
	Piedmontese lines	1,030
	Lombard lines	477
	Central Italian lines	294
	Venetian lines	437
	Total	2,238
Roman Railway Company:		
South section	Naples and Leri, Cancello and St. Severino Railway.	181
	Ancona and Orte Railway..	238
North section	Leghorn, Azetina and Ligurian lines	761
	Empoli, Siena and Orvieto Railway	216
	Total	1,396
Southern Railway Company:		
	Mediterranian network	183
	Adriatic network	984
	Voghera, Pavia and Brescia Railway Company	149
	Total	1,316
Victor Emmanuel Railway Company:		
	Palermo and Termini Railway	37
	Messina and Catania Railway	95
	Reggio and Lazzaro Railway	17
	Total	149
Total of four groups		5,099
Turin and Cirie Railway		8
Fell Railway over Mont Cenis from Susa to Frontier		27
	Total	5,134

A NEW ENGINEERING FEAT is talked of at Chicago. It is proposed to cut off the river several miles above the city, and conduct its entire volume of water to the lake by a canal, and convert the channel into a system of railroads, where all the lines converging in the city might meet in one grand central station.

THE CORNWALL BRIDGE.—The bill passed in the State Assembly for the construction of a suspension bridge across the Hudson river, 42 miles above New York city, appears likely to be acted upon, and the designs and calculations for the structure are now almost completed. The total length of the bridge, including approaches, will be 2,499 feet, the length between towers, 1,665 feet; the clear span, 1,600 feet; the height of the towers, 280 feet; distance from platform to water level, 150 feet. One of the towers will be in 30 feet of water, the other will be a land pier. The bridge will be carried by twenty cables disposed in four systems; each cable will be fourteen inches in diameter, formed of steel strands, disposed as in Mr. Roebling's bridge at Cincinnati. (It is now proposed to make the cable of steel bars.—Ed. V. N. Eng. Mag.) There will be 58,084 cubic yards of masonry in the tower.

There will be a road platform as well as a railroad track, which latter is calculated to a working load of 2,400 tons. The platform of the bridge would be filled by 32 passenger cars, or 53 locomotives, and 18,000 people, whilst the working strength allows for the crowding of 34,560 people and 60 locomotives upon the platforms at one time.

The bridge, which is estimated to cost about £500,000, will connect the mining districts of Pennsylvania with the New England States, and effect a saving of four shillings a ton on the 4,000,000 of tons of coal now consumed annually in New England. At present about 1,000,000 tons are carried every year down the Hudson to the depots along the coast. By means of a short branch made to the bridge, the Erie railway will be enabled to obtain a station in New York, and be saved the expense and inconvenience of transferring passengers and goods by ferry to their terminal station in Jersey City.

Pending the completion of the bridge, a ferry will be established at the point of crossing, for transfer of the traffic, as the railway will be completed up to the east and west banks of the Hudson long before the permanent connection can be made.—*Engineering.*

WOODEN MINING RAILWAYS.—The wooden railroad now completed between Clifton and the Adirondack mines in New York, is described as follows: The rails are of hard maple scantling, 4 x 6 inches, set on edge in slots in round ties, and keyed in the slots by two wooden wedges driven against each other, project two inches above the ties. The rails admit the bending sufficiently to make the curves.—The ties are laid on the earth and ballasted in the usual manner to two inches of the bottom of the rail. It takes 21,120 feet, board measure, of scantling for a mile, and 1,760 ties at three feet apart. The road is a very rough one, with a great deal of trestle work, some of it over 30 feet high, which is vastly more expensive than a level route. The engines used weigh from ten to fourteen tons. The rails will probably last about five or six years. An engine will move about 30 tons of freight at about six to eight miles an hour, with heavy grades and sharp curves. The company expects to move over the road next year from 50,000 to 1,000,000 tons freight. Trains have passed over the road, light, at the rate of twenty miles an hour; but this would not do for freight.

The proposition to build a wooden track railway along the Lake Superior copper range from Portage Lake to the Cliff mine has met with great public favor. The cost, except the first five miles to gain the summit of the range, has been estimated (wooden track) at $4,000 per mile; the bidding price for timber prepared and delivered being $2,300 per mile, leaving $1,700 per mile for construction account. This is considered more than sufficient, as all agree the labor will be no greater than that of making a common wagon road or earth-covered corduroy, which is done generally for about $4 or $5 per rod, or $1,250 to $1,600 per mile.

THE FIRST EFFECTIVE LOCOMOTIVE IN AMERICA.—The first effective locomotive engine in America—the "Old Ironsides"—says Mr. E. Haskill, in the "Coachmakers' Journal," was buil in Philadelphia, from a draft by Rufus Tyler, a brother-in-law and partner of the late Matthias Baldwin. In consequence of a misunderstanding the copartnership was dissolved, and Mr. Baldwin completed the engine in 1832. The wheels were made of wood, with broad rims and thick tires, the flange being bolted on the side. The engine was first put in motion on the Germantown and Norristown railroad. She ran a mile an hour, and was considered the wonder of the day. On trial it was ascertained that the wheels were too light to draw the tender, and to overcome this difficulty the tender was placed in front of the engine, which kept the wheels on the track. Mr. Baldwin and his assistants pushed the engine ahead until it attained some speed, when they all jumped on, their weight keeping the wheels from slipping. The boiler being too small for the engine, steam was only generated fast enough to keep the engine in motion a short time, so that they were compelled to alternately push and ride until they arrived at the Germantown depot. The return trip to Philadelpnia was performed by alternately riding and pushing in the same manner.

Several successive trials were had during the year following; after each, Mr. Baldwin added improvements and made alterations in its mechanism. That same engine is still in existence in Vermont.

RAILROAD MATTERS IN CALIFORNIA.—The open winter has been favorable to railroad enterprises on the Pacific slope. The Central Pacific has been enabled to push forward supplies, and to continue grading and track-laying without interruption. The new mineral discoveries in Nevada will much increase the traffic on this road through California and Nevada; indeed, the way business generally on both ends of the Pacific railroad has exceeded all expections for so early a period.

There are some signs of activity on the Western Pacific railroad, from Sacramento to Oakland. Meanwhile the California Pacific, via Vallejo, has reached Sacramento, and the passenger traffic is steadily increasing. The connection with the Napa Valley railroad is progressing. The extension to Marysville is expected to be completed by the middle of summer. Marysville will soon have railway connection with Sacramento on the east side of the Valley, through the Central and Yuba lines.

The Southern Pacific railroad is graded from San Jose to Gilroy, and some 30 miles of track nearly completed.

BALTIMORE UNION RAILROAD.—This enterprise was started some time since, with a view of giving an outlet at tide-water to the various railroads, built and contemplated, entering the city on its north side. It is likely to be fully completed during the ensuing two years. The contractors are, it is said, pushing it forward as rapidly as prudence will allow, and the road will have a tunnel just out of the city some 2,900 feet long. Three shafts have been sunk, but the difficulty of water is so great that the question of making an open cutting to be afterwards arched and filled in is being discussed.

SPANISH RAILWAYS.—The entire railway system in Spain is, in length, about 3,125 English miles, and about £60,450,000 have been expended, without in the aggregate ever having a farthing for distribution as profit. The railways were built extravagantly, they are ill fed for want of good carriage roads in the country, and altogether they are perhaps the most abject failures ever witnessed.—*Bulleonis.*

STOCKHOLM JUNCTION RAILWAY—ENGINEERING DIFFICULTIES.—The railway termini of this city have heretofore been at its extreme opposite ends. The new junction line commences at the southern end by entering a tunnel bored through solid granite, and describing a slight curve on plan. This tunnel is 1,500 feet long and 32 feet wide by a height of 19 feet, and passes under a very populous part of the city. Then follows a cutting 2,400 feet long, the retaining walls on either side being 30 feet high, executed in solid masonry. Next comes a bridge across the Söder, after which the line traverses the 'Stad' quarter, then crosses the Riddaneholm canal, and lastly joins the Northern railway over a high embankment. Considering the short distance, perhaps no line in the world has presented greater difficulties to the engineer, and it is only in Sweden that this could have been effected at so low a cost, namely, about £61,000. The granite in the tunnel was blasted by means of nitro-glycerine, 30,000 pounds being used in the operation.

FRENCH RAILWAYS.—The entire extent of railway in operation in France, Stptember 30, 1868, was 9,934 miles as compared with 9,671 miles September 30, 1867, showing an increase of 263 miles.—The entire amount earned n all the French railways to September 30 this year, was £19,684,405, as compared with £19,424,998 in the corresponding nine months of 1867, showing an increase of £259,407 this year. This increase was entirely attributable to the new network and the miscellaneous lines, the old network presenting a decrease in the first nine months of this year of £188,156. The general result of the working of the French lines of the first three-quarters of this year was a decrease of 4.78 per cent per mile worked, as compared with the corresponding period of 1867; but a somewhat better result may be anticipated for the last quarter of the year. Nevertheless, French railway traffic has shown less elasticity in 1868 than in several preceding years.—*Herapath's Railway Journal.*

THE GAUGE QUESTION.—The narrow gauge is now replacing the broad gauge system on several of the branches of the Great Western railway. This change will doubtless lead to some legal difficulties, certain coal merchants having built a number of broad gauge trucks, and made contracts with the company for the conveyance of coals therein for a period of several years. It is understood that orders have been received at the workshops of the Delaware, Lackawanna and Western railroad, in Scranton, to rebuild no more locomotives for the wide gauge.—This looks to the not distant laying of the third rail, which is also necessitated by the leasing of the Morris and Essex railroad.

BRITISH RAILWAY MILEAGE RECEIPTS AND EXPENSES.—The earnings of British railways per mile worked have shown a steady tendency to increase upon the whole. In 1849 the total receipts per mile were £1,957; in 1850, £1,994; in 1851, £2,176; in 1852, £2,141; in 1853, £2,345; in 1854, £2,510; in 1855, £2,580; in 1856, 2,660; in 1857, £2,559; in 1858, £2,510; in 1859, £2,574; in 1860, £2,661; in 1861, 2,629; in 1862, £2,522; in 1863, £2,528; in 1864, £2,667; in 1865, £2,700; in 1866, £2,755; in 1867, £2,770. But while the working expenses of British railways were 46.83 per cent of the traffic receipts in 1849, they had increased to 54.57 per cent of the receipts in 1867.

TRAFFIC OF THE METROPOLITAN RAILWAY.—It is officially stated that during the six days of the Christmas holidays, from the 24th to the 30th, 800,072 passengers passed along the lines of this company.

A RAILWAY LIBRARY of 1,000 volumes has been established by the Boston and Albany railroad. An apartment in the passenger station at Boston has been fitted up for it. The library is divided into two departments, the Consulting and the Circulating.—The first comprises railway enactments, English and American; encyclopedias. The circulating department embraces standard works of interest, instruction, fiction, and bound volumes of the most valuable periodicals of past years, 500 or 600 in number. Any person in the service of the company on the line between Boston and Albany is privileged to take books from this department, two at a time, and to hold them two weeks, the train baggage-masters and station agents along the route transmitting them on Tuesday and Thursday of each week.

THE TWELVE GREAT RAILWAY COMPANIES of Great Britain are: The Caledonian; Great Eastern; Great Northern; Great Western; Lancashire and Yorkshire; London and Northwestern; London and Southwestern; London, Brighton and South Coast; Manchester, Sheffield and Lincolnshire; Midland; Northeastern, and Southeastern. The twelve lines own 6,595 locomotives, valued at over eighty millions of dollars.

WARMING STREET CARS.—The cars of the Albany and West Troy railroad (seven mile route) are warmed by stoves. The stove occupies the place of one passenger (or what would be appropriated to say three passengers in New York city); it rests on the bottom of the car and passes through the seat. The adjacent passengers are protected by high screens.

LARGE LOCOMOTIVES.—The 4-cylinder goods engines on the Northern railway of France weigh 59 tons, and have 17½ in. cylinders, 17½ in. stroke, and 12 coupled wheels 3 ft. 6 in. in diameter. The "Pennsylvania," on the Reading railway, has 2 cylinders 20 in. in diameter, 26 in. stroke, and 12 driving wheels 3 ft. 11 in. in diameter. Some of the Great Northern (England) engines weigh 56 tons.

NEW LINE FROM EUROPE TO INDIA.—The railway just commenced from Constantinople to Adrianople, will ultimately join the Austrian lines at Belgrade, and complete the European part of the Euphrates Valley line to India. This accomplished, its prolongation either along the Euphrates Valley or that of the Tigris can be but a question of time and policy.

ANOTHER TRANS-CONTINENTAL RAILWAY.—It is stated that the Czar of Russia has sent two engineers to inspect the Pacific railroad, with a view to utilizing whatever information they may obtain in the construction of a road from St. Petersburg to Chinese Tartary.

THE RAILWAY MANIA.—A period of remarkable activity in railway construction is just commencing. Cannot promoters and managers be persuaded to avoid the grand mistake of former times—*bad work*, costly to maintain, unsafe, and ruinous in the end.

LOCOMOTIVE CARS.—"The Engineer" states that arrangements are being made for working a section of one of the largest railway systems in England on the steam carriage principle.

THE BRIDGE AT COLUMBIA.—The Pennsylvania railroad bridge spanning the Susquehanna at Columbia was opened to general travel on January 4.

NEW BOOKS.

A HANDY BOOK FOR THE CALCULATION OF STRAINS IN GIRDERS AND SIMILAR STRUCTURES AND THEIR STRENGTH, CONSISTING OF FORMULÆ AND CORRESPONDING DIAGRAMS, WITH NUMEROUS DETAILS FOR PRACTICAL APPLICATIONS, &c. By WILLIAM HUMBER, ASSOC. INST. C. E. Author of a practical treatise on cast and wrought iron bridge construction, a Record of the Progress of Modern Engineering, &c. 12mo. with three plates and nearly 100 wood cuts.

Mr. Van Nostrand is photographing the plates and text of this work and will issue it in a few days.

The "Builder" speaks of the work as follows: This volume is not intended to supersede larger and more elaborate treatises. It is intended to take a place midway between these and the "Engineer's Pocket-book" class. The former are too elaborate for convenient use, the latter have not space enough for the introduction of many useful formulæ. The "Handy Book" represents the mean between the two extremes, and will be found a valuable companion by the practical man. The author not only gives the most applicable formulæ for particular cases, but he illustrates them by means of excellent diagrams, and thus makes his subject easily intelligible to any one whose mathematical knowledge extends to equations. The method of drawing a parabola—the base and height being stated—which Mr. Humber gives, is a happy one. The book indeed recommends itself better than any notice we could write.

THE INDICATOR DIAGRAM PRACTICALLY CONSIDERED. By N. P. BURGH, Engineer. London: E. & F. N. Spon, 1869.

This is a 12 mo. of 160 pages, containing numerous wood-cuts. The object aimed at is best stated in the words of the preface. "The means I adopted" to professionally test some indicator diagrams "were to consider, first, the proportions of the details that regulated the admission, expansion and exhaustion, of steam; and, secondly, their geometrical delineation. Having proceeded thus far, I then concluded that, as the length of the motion for the indicator barrel was virtually that of the stroke of the piston, the scale of the geometrical test that I employed must be subject to that circumstance. I accordingly made a drawing of the cylinder ports, slide valve, link motion, eccentrics and rods, a portion of the length of the piston, length of the connection rod and crank circle at the same scale that the stroke of the piston, in inches, was equal to the length of the indicator diagram. I acquired thus a correct knowledge of the positions of all the details that regulated the steam at the points of admission, cut-off, expansion, exhaustion, compression and lead, in relation to the positions of the piston and crank pin at the same scale as at the diagram; and by laying it on the crank pin's circle, I saw at once *how it was formed in relation to time and speed*, and the *cause of the defects*, if any existed—indeed being the only method of gaining that information *truthfully*, which is illustrated by the plate in the frontispiece."

The work also treats of the indicator and diagrams in all their points and relations.

LONG AND SHORT SPAN RAILWAY AND HIGHWAY BRIDGES. By J. A. ROEBLING, C. E.

Mr. Van Nostrand is producing this work in superb style. It is a large folio, eighteen by twelve inches, with folding plates; some of them 60 inches long, engraved on copper. It will be ready in April.

Mr. Roebling's name, alone, will insure a large sale for this work. The results of his labors and studies, all these many years of devotion to the subjects of iron, steel and bridges, will be eagerly sought for by the profession all over the world.

THE ONE GREAT FORCE. The Cause of Gravitation, Planetary Motion, Heat, Light, Electricity, Magnetism, Chemical Affinity, and other Natural Phenomena. By CRISFIELD JOHNSON. Buffalo: Reed & Lent.

The author of this little work first calls attention to the steadily increasing belief among the leaders of the scientific world that heat, light, electricity, magnetism, and chemical affinity are all manifestations of the same force and convertible into each other, and, after reference to Faraday's essay on the "Conservation of Force," and to Grove's doctrine of the correlation of forces, lays down the proposition that "The one great force of the material universe is the self-repulsion of caloric acting on the inertia of ordinary matter." This force, he asserts, is the source or cause of attraction, heat, light, gravitation, capillary attraction, planetary motion, electricity, magnetism, cohesion, adhesion, chemical affinity, combustion, explosion, tides, the building power of animals and plants, and the circulation of the blood. If he does not prove the truth of his proposition, he at least shows the probability of its correctness. We recommend the book to the study of all who take an interest in the subject of the origin of natural forces. *American Artisan.*

ENGINEERING. AN ILLUSTRATED WEEKLY JOURNAL. Conducted by ZELAH COLBURN. London: 1869.

The seventh volume of this most excellent journal is fully up to the previous volumes in extent and quality of matter. We do not see how any engineer who is familiar with Mr. Colburn's writing—his extensive, positive and practical knowledge, and his clear, concise, searching and comprehensive treatment—can do without this journal. In the pretty careful reading of 50 to 70 scientific magazines and newspapers every month, we find much that is thoroughly good and well put, and a great deal that is inconclusive, if not trivial. But we rarely find anything in Mr. Colburn's writings that is not founded upon large views and extensive reading and experience. Even when somewhat hasty and incomplete, as newspaper articles must be, in comparison with exhaustive treatises, Mr. Colburn's articles are full of ideas, apt illustrations and strong points.

A MANUAL OF ELEMENTARY CHEMISTRY, THEORETICAL AND PRACTICAL. By GEO. FOWNES, F. R. S., late Professor of Chemistry in University College, London. Tenth edition, revised and corrected. London: JOHN CHURCHILL & SONS, New Burlington street, 1868.

There is probably not a student of chemistry in this country to whom the admirable manual of the late Professor Fownes is unknown. It has achieved a success which we believe is entirely without a parallel among the scientific text-books in our language. This success has arisen from the fact that there is no English work on chemistry which combines so many excellences. Of convenient size, of attractive form, clear and concise in diction, well illustrated, and of moderate price, it would seem that every requisite for a student's handbook has been attained.—*Chemical News.*

A SYNOPSIS OF THE PATENT LAWS OF VARIOUS COUNTRIES. By ALEX. TOLHAUSEN, Ph. D., Translator at the Patent-office, London: TRUBNER & Co.

This work contains, in a condensed form, all the necessary information respecting fees, documents required, disclaimers, prolongation, infringements, jurisdiction, and legal proceedings, &c., &c., together with references to the acts and ordinances themselves. An eager inventor can now ascertain, in a few minutes, the entire cost of patenting his invention in every quarter of the globe.

TRAITÉ ÉLÉMENTAIRE DE PHYSIQUE, PAR A. PRIVAT DESCHANEL, Professor au Lycée Louis le Grand. Paris: 1868.

This work would have been called a "Natural Philosophy" in our school days, but it is rather in advance of the "Comstock's Philosophy" we studied, in style and treatment. It appears to be even an improvement on Ganot, which is saying a great deal. We hope it will be translated, and, above all, that the wood-cuts will be reproduced in something like the French style of high art. The pre-corlissite treatment of the steam engine, for instance, in most of our modern text books, and the pre-raphaelite wood-cuts that disfigure them, are unworthy of the aspirations of American youth, and the pretensions of American publishers.

ELEMENTARY GEOMETRY. By J. M. WILSON, M. A., Fellow of St. John's College, Cambridge, and Mathematical Master at Rugby School. Macmillan & Co.

This is an attempt considered very promising by reviewers, to render an exceedingly dry subject attractive, and hence familiar and useful. The arrangement and treatment of the facts are changed, and practical applications of geometry are introduced. Several attempts had previously been made in England to make Euclid more practical, but they have not been very successful there. In France, on the contrary, Legendre and La Croix each composed elements which have completely supplanted Euclid. It is their models that Wilson has greatly followed.

ART OF CONSTRUCTING AND REPAIRING COMMON ROADS. Weale's Rudimentary Series. London: Virtue & Co., 1868.

A fourth edition of this volume of Weale's Rudimentary Series, with additions, has been published. It includes a "Survey of the Metropolitan Roads," by S. Hughes (which might be left out without much loss); the "Art of Constructing Common Roads," by Henry Law; "Remarks on the Maintainance of Macadamized Roads," by Sir John Burgoyne; and a note by Mr. Robert Mallet on the causes of the apparent failure of macadamized roads in certain localities. Mr. Mallett regards asphaltic macadamizing as the very best material for the street surfaces of populous cities. A large amount of valuable instruction is given.

MOLECULAR AND MICROSCOPIC SCIENCE.—By MARY SOMERVILLE, in two volumes. London: John Murray. 1869.

The scope of the work is thus stated in the prefsce: "Microscopic investigation, organic and inorganic, is so peculiarly characteristic of the actual state of science, that the author has ventured to give a sketch of some of the most prominent discoveries in the life and structure of the lower vegetable and marine animals, in addition to a few of those regarding inert matter." The work is quite fully illustrated.

THE MONTHLY MICROSCOPICAL JOURNAL.—TRANSACTIONS OF THE ROYAL MICROSCOPICAL SOCIETY, AND RECORD OF HISTOLOGICAL RESEARCH AT HOME AND ABROAD. Edited by HENRY LAWSON, M. D., F. R. M. S., London. No. 1, Jan. 1869. This is a new illustrated Journal of this important and growing science.

TABLES SHOWING THE LENGTH, IN FEET, OF A DEGREE, MINUTE, AND SECOND OF LATITUDE AND LONGITUDE, WITH THE CORRESPONDING NUMBER OF STATUTE MILES IN EACH DEGREE OF LATITUDE, &c., &c. By R. C. CARRINGTON, F. R. G. S., of the Hydrographic Department of the Admiralty.

QUANTITIES MADE EASY; A QUICK AND ACCURATE METHOD OF TAKING OUT QUANTITIES IN BUILDINGS. By H. A. CREASEY. F. SHAW, Dockhead.

These pages consist of lists of the items in an ordinary dwelling house, so that an estimator may not forget or overlook any in taking out his quantities. Instead, however, of keeping all the trades separate, the writer puts each room separately, so that the same headings would have to be written over and over again, and the resulting sum would be very much higher than the same estimator would bring to it if he pursued the more customary, expeditious and common-sense mode.

A TEXT-BOOK OF NATURAL PHILOSOPHY. An accurate Modern and Systematic Explanation of the Elementary Principles of the Science. Adapted to use in High Schools and Academies. With 149 illustrations. By LE ROY C. COOLEY, A. M., Prof. of Nat. Science in the N. Y. State Normal School. Pp. 315. New York: Charles Scribner & Co., 654 Broadway.

The author discourses of molecules and molecular motions, having cut adrift the ancient theory of imponderables. He has no respect for error because it is venerable, and he gives it no room in his book. He sets a good example to the *compilers* of school-books of science.—*Chemical News.*

DICTIONARY OF ENGINEERING, CIVIL, MECHANICAL, MILITARY, AND NAVAL, WITH TECHNICAL TERMS IN FRENCH, GERMAN, ITALIAN AND SPANISH. E. & F. N. Spon. London: 1869. Part I.

This work appears, upon a cursory examination, to be full of useful and *modern* practice. It is very liberally and well illustrated. The "Engineer" and other authorities criticise some of its articles very freely, but all of them, on the whole, commend it. It cannot fail to be important and valuable.

UNDERGROUND LIFE, OR MINES AND MINERS. By L. SIMONIN. TRANSLATED, ADAPTED TO THE PRESENT STATE OF BRITISH MINING, AND EDITED BY H. W. BRISTOW, F. R. S., of the Geological Survey. Illustrated with many plates, including chromo-lithographs. London: Chapman & Hall, 1869.

This is a beautifully printed and illustrated work, and will prove very entertaining to all readers, professional or otherwise.

THE RAILWAYS OF INDIA, WITH AN ACCOUNT OF THEIR RISE, PROGRESS AND CONSTRUCTION; WRITTEN WITH THE AID OF THE RECORDS OF THE INDIA OFFICE. By EDWARD DAVISON, Captain, R. N. London: E. & F. N. Spon. 1868.

THE CHEMICAL NEWS, Vol. IX, 1869. The papers in this volume are, so far, interesting to all classes of readers, especially the articles on food, sewage and water supply.

SANITARY SIFTINGS, OR RESULTS OF SEWAGE SYSTEMS COMPARED. London: E. and F. N. Spon, Charing Cross.

THE A.B.C. SEWAGE PROCESS. London: Yates & Alexander, 7 Symonds Inn, Chancery Lane.

NAVIGATION AND NAUTICAL ASTRONOMY.—J. Merrifield and H. Evers. 8vo., 14s.

COURS DE CHIMIE AGRICOLE. Par M. G. LECHARTIER. Paris.

VESUVIUS. By JOHN PHILIPS, M. A. Oxford: 1869.

COURS DE MÉCANIQUE. Par M. EMILE LECLERT, Paris.

MISCELLANEOUS.

TABLE OF FRENCH AND ENGLISH WEIGHTS.

From "The Engineer."

Kilos.		lb.	lb.		Kilos.
0.500	=	1.1028	1	=	0.4534
1.000	=	2.2055	2	=	0.907
2.000	=	4.4110	3	=	1.360
3.000	=	6.6165	4	=	1.814
4.000	=	8.8220	5	=	2.267
5.000	=	11.0275	6	=	2.721
6.000	=	13.2330	7	=	3.174
7.000	=	15.4385	8	=	3.627
8.000	=	17.6440	9	=	4 081
9.000	=	19.8495	10	=	4.534
10.000	=	22.0550	15	=	6.801
11.000	=	24.2605	16	=	7.255
12.000	=	26.4660	17	=	7.708
13.000	=	28.6715	18	=	8.161
14.000	=	30.8770	19	=	8.615
15.000	=	33.0825	20	=	9.068
16.000	=	35.2880	28=1 qr.	=	12.695
17.000	=	37.4935	56=2 qrs.	=	25.391
18.000	=	39.6990	84=3	=	38.087
19.000	=	41.9045	112=4	=	50.782
20.000	=	44.100			

Cwt.		Kilos.	Tons.		Tonnes.
1	=	50.782	1	=	1.0157
2	=	101.564	2	=	2.0313
3	=	152.347	3	=	3·0470
4	=	203.129	4	=	4.0626
5	=	253.912	5	=	5.0782
6	=	304.695	6	=	6.0939
7	=	355.477	7	=	7.1095
8	=	406.260	8	=	8.1252
9	=	457.042	9	=	9.1409
10	=	507.825	10	=	10.1565
20=1 ton	=	1,015.649			

Avoirdupoise.

1 oz.	=	28.3380 grammes
1 lb.	=	0.4534 kilogrammes
1 qr.	=	12.6950 kilogrammes
1 cwt.	=	50.7800 kilogrammes
1 ton	=	1.015.650 kilogrammes
1 gramme	=	15.438 grs. troy=0.0353 oz. avoirdupois
1 kilogramme	=	2.2055 lb.
1 tonne	=	0.9846 ton=19 cwt. 2 qr. 21½ lb.
1s. per lb.	=	2.757f. per kilogramme
1f. per kilogramme	=	4.353d. per lb.
£1 per ton	=	24.615f. per tonne.

MOVING CITY BLOCKS.—In the new Boston improvements, this is accomplished in the following manner: About six houses, or one hundred and twenty feet long, are usually raised in one block together, the walls, front and back, being cut, or rather a line of separation being made at about each sixth house. The raising is done by screws, as usual, and the blocking is the usual cob-house work of pieces of timber. The moving is on wooden rollers, round iron bars, and on balls, with no apparent reason for choosing or using either. Of course, those houses at the ends of each block, in raising, where the party wall is removed, are carefully clamped and braced. And about every fourth house has been found to require the front and back walls to be clamped by through bolts to the floors. The walls may be said to be universally but eight inches—one brick thick. *About one-half the houses are occupied*, the raising or moving not interfering with the domestic comforts of the household. From an examination of the buildings, very few cracks are discernable. The ground is fortunately all solid, not "made," and the underpinning is either done in brick or in cubical granite blocks.

SUBMARINE BLASTING AT HELL GATE.—The apparatus designed for drilling the sunken rocks for the introduction of the charge, consists of a water-tight iron casing, in form a depressed semi-spheroid, seven feet in diameter. It has three solid steel feet by which its stability on the rock is secured. Rising from the upper part of the casing is a conical wrought iron frame, supporting the upper end of the drill shaft by means of two parallel rods entering into sockets in a cast ring at the top of the frame. The drill bar passing up through the center of the top is furnished at the bottom with a bit, one and a half inches diameter, having imbedded in its face nineteen diamonds, and rotating at the rate of from 300 to 500 revolutions per minute, advancing at the rate of from one to one and a half inches in the same time. The feed is caused by a differential gearing which steadily operates to advance the drill into the rock, the debris being washed away by the water forced into contact with the bit through a small rubber hose. The water-tight chamber of the machine contains a pair of engines working at right angles to each other, with a horizontal stroke. As soon as the hole is completely drilled, and also when the drill shaft is withdrawn from the rock, information of this is given by a magnetic bell which is acted upon by a double wire cord insulated from the water and passing down one of the parallel rods or tubes upon which the crosshead is fixed. This drill weighs nearly five tons. It is worked from a wrecking tug with a derrick by means of steam supplied from the boiler of the tug. To prevent this steam being condensed in its passage through the water to the engine it is conveyed in a hose surrounded by another through which the exhausted steam passes. The rock at Hell Gate is that known as the bastard granite, and is much softer than either the Quincy or Maine granite, on which the drill has been satisfactorily tested. After a number of holes are drilled over a certain space, a diver descends and charges them with cartridges of nitro-glycerine, which is exploded in the usual manner. The fragments are raised by automatic grapnels.

OPINIONS DIFFER.—A prominent London cotemporary says about two inventions, one English and the other American, both of which are recognized by the best and most numerous authorities as among the most successful improvements of modern times, as follows:—

Siemens' furnaces do not gain in favor. Those put down at the Woolwich Gun factory are not used, as they were not economical. In Prussia, we understand that they make no way, and the statement is indirectly supported by another which has reached us to the effect that, although used at Elswick, they cost 30 per cent more in fuel than the common furnaces.

Mr. Isherwood, the chief engineer of the United States navy, has reported dead against the monitors, and the secretary of the United States navy coolly suppressed this portion of the report. The American government are building no monitors, and both the Dictator and the Puritan have been pronounced total failures. Turret ships are increasing in favor in Europe, but they must not be confounded with the Ericsson monitor, which is a very different thing.

TRIAL OF STEAM ROLLERS.—A successful public trial has been made at Rochester of a steam road roller, manufactured by Messrs. Aveling and Porter, for the city of New York. An incline having a rise of 1 in 12, was chosen for the trial, its entire surface being covered with the ordinery stones used on macadamised roads. In six hours the road was completely smooth and fit for the passage of vehicles. Messrs. Aveling and Porter have in hand three similar rollers for the Indian authorities.

WESTERN RIVER NAVIGATION.—The Pittsburgh "Chronicle" gives the following figures concerning the number and tonnage owned in the different States along the Mississippi and its tributaries:

	Barges.	Steam vessels.	Total tonnage.
Louisiana	33	230	55,328.67
Mississippi	..	15	2,396.33
Tennessee	..	63	13,412.83
Kentucky	14	75	27,372.83
Missouri	98	210	112,123.18
Iowa	28	28	5,002.29
Minnesota	87	53	18,982.01
Illinois	99	72	27,323.65
Indiana	..	26	5,293.88
Ohio	70	165	98.714.45
West Virginia	20	124	22,115.42
Pennsylvania	385	197	93,152.03
Total	834	1,263	481,217.61

HOT PRESSED NUTS IN ENGLAND.—American machinery for making nuts has been introduced in Birmingham. The process may be thus briefly described: The puddled iron is placed in a reverberatory furnace, rolled to the requisite size, and while still hot is placed in the machines. Here the iron is cut off, forced into a die box, either square, hexagonal, or octagonal, as the case may be, and while under the necessary pressure it is punched simultaneously from either side. The advantages of this process are the greater cohesive strength arising from the hole being forced into the nut, thereby solidifying the metal; the certainty with which the hole is made exactly central, as well as smooth and true throughout; the regularity and quality of the angles; complete uniformity of size; and rapidity of production. Fifty to eighty nuts can be produced per minute. Bolts are produced by other machines at a single blow.

NOVEL USE OF THE CAMERA OBSCURA.—Some officers of engineers have just been making experiments at Antwerp as to the means of defending the passes of the Scheldt by a system of torpedoes placed in three lines, the explosion of which is regulated by the use of a camera obscura. The instrument is fixed at a certain point, and whenever a ship passes over it, its image is reflected on the mirror at the camera. When the image arrives at a certain determined point, the eclectric current is applied, and the explosion takes place immediately. The mines are numbered, and each has a corresponding mark in the chamber. The method of observation is simple and sure, and was adapted for the defence of Venice in the late Italian war. The trials succeeded perfectly, and are soon to be repeated on a larger scale.

TWENTY-FOUR POUND BOAT.—Walter Brown, the champion oarsman, has lately built a single scull outrigger shell of Spanish cedar, 30 feet seven inches long, twelve inches wide, and six and three-eighths inches deep amidships; four feet and eleven inches wide across the rowlocks, eight inches deep aft, and four and a half inches forward; weight 24 pounds. She is nearly finished now, and weighs only eighteen pounds. He is building another boat of the same size, which will weigh only nineteen pounds. The lightest boat heretofore built, of the same size, was that in which Brown rowed at Pittsburg last September. This was made of paper, and weighed 27¼ pounds.

SCREWS VS. PADDLE.—The Cunard paddle steamer Persia has been turned into a sailing vessel with auxiliary screw. The Cunard paddle steamer Scotia is to be converted into a screw.

PAPERSON CONSTRUCTION.—We have in type the first of a valuable series of articles on this subject, which will extend through several numbers of the magazine. Various papers on construction are in course of publication, in the home and foreign serials. While they are generally useful, we think that some of them are too elementary, others too abstruse, and others still too limited in scope to meet the requirements of our readers. A compilation of such miscellaneous elements would hardly answer the purpose. We have therefore secured the preparation of a series of *original papers*, by an engineer officer, whose education and practice have thoroughly fitted him for the work.

THE ROGERS LOCOMOTIVE WORKS employ 3,000 hands, and turn out about ten locomotives per month, besides an immense quantity of cotton and woolen machinery. The works comprise one building 200 by 32 feet, and one 102 by 40, with boiler shop, erecting shops and several other structures. This establishment was founded in 1831 by Thomas Rogers, and turned out its first locomotive for the Mad River and Lake Erie Co., in 1838.—*American Railway Times.*

WORKS FOR UNLOADING COAL AT NEW HAVEN.—Hawkins, Herthel and Burrall of Springfield, Mass., have a contract, amounting to upwards of $40,000, for building a new coal wharf for the Hartford and New Haven railroad at New Haven. In connection with the wharf, which is to be 1,000 feet long and 50 feet wide, will be four elevators, capable of storing 1,000 tons of coal.

THE BOSTON ELEVATOR, building by the Boston and Albany Railroad Co., is constructed of brick and wood; it is 70 feet high. The upper story will contain 82 bins; the total capacity will be 250,000 bushels. It is stated that a car can be emptied in ten minutes, and that the cost of elevating and storing will be one cent per bushel for the first five days, and storage extra after that time.

BLASTING GRANITE.—In one of the granite quarries, near Penryn, a large mass of sound granite has been moved from its natural bed some inches, by 50 lb. of blasting powder, confined in a hole 12 ft. deep and 6¼ in. in diameter, bored in the rock. The stone measures, at least, 40 ft. by 40 ft. by 12 ft., which equals 19,200 cubic feet, or 1,280 tons.

THE MERCANTILE LIBRARY of New York has now 100,000 volumes, embracing the best works on every topic. Popular works are largely duplicated, and about 10,000 volumes are added yearly. The reading-room is large, well-warmed, well-lighted, and supplied with 3,000 books of reference, and over 400 periodicals, foreign and domestic.

ELECTRIC CLOCKS.—Kennedy's, exhibited in New York, are driven by the current of an earth battery, and require no winding up. All the clocks in a house or locality, or on a line of railway, may, it is alleged, be driven by the same battery, and keep the same time, tick for tick.

STEAMSHIP CONSTRUCTION.—The promised article treating this subject generally, has been crowded out by two articles referring to the marine engine particularly—the Hercules, and Morton's Condenser—but will appear in our next number.

THE P. AND O. FLEET.—The steam fleet owned by the Peninsular and Oriental Company comprises a total of 48 ocean-going vessels, having an aggregate tonnage of 85,632 tons and 18,520 horse power.